

CALIFORNIA INSTITUTE OF TECHNOLOGY

EARTHQUAKE ENGINEERING RESEARCH LABORATORY

ANALYSES OF STRONG MOTION EARTHQUAKE ACCELEROGRAMS

VOLUME IV - FOURIER AMPLITUDE SPECTRA

PARTS Q, R, AND S

ACCELEROGRAMS IIQ233 TO IIQ243, IIR244 TO IIR254,
AND IIS255 TO IIS273

REPORT NO. EERL 74-104

A REPORT ON RESEARCH CONDUCTED UNDER A
GRANT FROM THE NATIONAL SCIENCE FOUNDATION

PASADENA, CALIFORNIA

OCTOBER, 1974

CALIFORNIA INSTITUTE OF TECHNOLOGY
EARTHQUAKE ENGINEERING RESEARCH LABORATORY

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STRONG MOTION EARTHQUAKE ACCELEROGRAMS

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ABSTRACT

This is one of a series of reports presenting Fourier amplitude spectra for earthquake ground motions and for structural response accelerations. Volume IV, Part A, Report No. EERL 72-100, included an introduction summarizing Fourier spectrum techniques in earthquake engineering as a background to the use of the data. For each earthquake accelerogram, two spectrum plots are given - a Fourier amplitude spectrum versus frequency on a linear scale and a log-spectrum, log-frequency plot. In this Volume IV series, Fourier amplitude spectra will be given for all corrected accelerograms, including building response measurements. The corrected records analyzed in this report, Volume IV, Parts Q, R, and S, appeared in Volume II, Parts Q and R, Report No. EERL 74-56, and Volume II, Part S, Report No. EERL 74-57. Their uncorrected versions were published in Volume I, Part Q, Report No. EERL 73-22; Volume I, Part R, Report No. EERL 73-23; and Volume I, Part S, Report No. EERL 73-24.

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PREFACE TO VOLUME IV, PARTS Q, R, AND S

This report, Volume IV, Parts Q, R, and S,* Report No. EERL 74-104, is part of the Volume IV series presenting Fourier spectrum curves calculated from corrected strong-motion accelerograms including measurements in structures as well as at ground sites. We continue here with records from the San Fernando, California, earthquake of February 9, 1971. The analysis of records from this earthquake appeared first in Volume IV, Part C, Report No. EERL 73-101, and this report presents the last of the San Fernando spectra, from the following locations:

1. 14724 Ventura Boulevard, Los Angeles (3 records)
2. 1760 N. Orchid Avenue, Hollywood (3 records)
3. 9100 Wilshire Boulevard, Beverly Hills (2 records)
4. 800 W. First Street, Los Angeles (3 records)
5. 222 Figueroa Street, Los Angeles (2 records)
6. 6464 Sunset Boulevard, Los Angeles (2 records)
7. 6430 Sunset Boulevard, Los Angeles (1 record)
8. 1900 Avenue of the Stars, Los Angeles (2 records)
9. 234 Figueroa Street, Los Angeles (2 records)
10. 533 S. Fremont Avenue, Los Angeles (2 records)
11. 6200 Wilshire Boulevard, Los Angeles (3 records)
12. 3440 University Avenue, Los Angeles (3 records)
13. 1177 Beverly Drive, Los Angeles (1 record)
14. 5900 Wilshire Boulevard, Los Angeles (3 records)
15. 3435 Wilshire Boulevard, Los Angeles (1 record)**
16. 3550 Wilshire Boulevard, Los Angeles (1 record)
17. 5260 Century Boulevard, Los Angeles (3 records)
18. 930 Hilgard Avenue, Los Angeles (1 record)
19. 11661 San Vicente Boulevard, Los Angeles (2 records)
20. 15433 Ventura Boulevard, Los Angeles (1 record)

*For reasons of economy and convenience in the size of the reports, it has been thought desirable to combine three parts into one report.

**The original address of this building, when the instruments were first installed, was 3411 Wilshire Boulevard.

The uncorrected versions of these records appeared in Volume I, Parts Q, R, and S, Report Nos. EERL 73-22, 73-23, and 73-24, and the plotted corrected accelerations, velocities, and displacements were included in Volume II, Parts Q and R, Report No. EERL 74-56, and Volume II, Part S, Report No. EERL 74-57. These Volume II corrections included a long period cut-off of 8 seconds for all the 35-mm film records in this issue instead of the standard cut-off period of approximately 15 seconds. This includes all the records in this issue. The results published here reflect this altered low-frequency limit most clearly in the log-log plots where the Fourier amplitude spectrum in general commences falling off at a frequency of $f = 0.125$ cps ($\log f = -0.90$) instead of a $f = 0.07$ cps ($\log f = -1.15$).

A number of very low amplitude accelerograms have been eliminated from the processing of Volume II and on, reflecting the expectation that the resulting displacements would be dominated by noise. None of the records in Parts Q, R, and S are included in this group of accelerograms.

A comparative study of ground level and roof records using Volume II corrected accelerations, velocities, and displacements brought to light the following facts regarding the time scales of the three records obtained from the building at 1760 N. Orchid Avenue in Hollywood. In Volume I, Part Q, a description can be found, on page 3, of the way in which the time scales were chosen for the records obtained at the ground, 12th, and 23rd floors. The ground floor record time marks were faint and intermittent, but an estimate could be made of the average film transport speed of 1.67 cm/sec.

The 12th floor record time marks could be digitized directly. There were no time marks on the 23rd floor record and a typical speed of 1.62 cm/sec was used. The investigation described in Volume II, Parts Q and R, has shown that the ground and 12th floor records match perfectly and that a more probable film speed for the 23rd floor record is 1.585 cm/sec, a reduction of 2.2%. This implies the following corrections for the three components of this record, Q238, in this report: All frequencies are to be decreased by 2.2%, or the multiplicative factor 0.978, while their logarithms are to be reduced by the value 0.0097.

A similar situation, although one not resolved as readily, occurred with the two records S271 and S272, at 11661 San Vicente Boulevard, Los Angeles, the 5th and 11th floors. Neither of these records had a time mark trace, and an average film speed of 1.62 cm/sec was used for the Volume I, Part S, uncorrected data. However, subsequent Volume II analysis of these records has shown that a good fit of the corrected velocity in the vertical direction could be obtained if the 11th floor record was extended with respect to the 5th floor record by 4.03%, i.e., by increasing the time coordinates of the 11th floor record by this percentage. No absolute time rate is available though, because of the three records available within two miles of this site, at 945 Tiverton (2 records) and 930 Hilgard, not one had an operating time mark trace. In all cases the corrected vertical velocity can be used to obtain relative film speeds by selecting appropriate peaks, and the 4.03% fluctuation above is the largest discrepancy between any two records. Because it is impossible at

this stage to determine the true time rates, no change has been made to the values of the frequencies in this issue. For investigators interested in consistency in this building, the values of the frequencies for record number IIS272 may be decreased by 4.03%.

A separate section included in this report entitled "High Frequency Amplitude Errors in Digitized Strong Motion Accelerograms" describes the results of a recent investigation of high frequency noise generated by the digitizing process. Frequencies from several to 25 Hz have been studied, and figures have been included to indicate clearly the extent to which Fourier amplitudes have been affected within this range.

NOTES ON THE VOLUME IV SERIES

Description of the Four Volumes of the Project. The series of reports in Volume I present "uncorrected" digitized and plotted strong-motion earthquake accelerograph data, while the series in Volume II present corrected digitized data prepared so that the maximum information over the widest practicable frequency range would be available. The corrections include long period filtering ensuring to the greatest extent possible a uniform type of baseline adjustment and an instrument correction to account for the high frequency response characteristics of the accelerograph transducer.

The Volume III series presents earthquake response spectrum curves calculated from the corrected accelerograms of Volume II, while the Volume IV series contains Fourier amplitude spectra calculated by the Fast Fourier Transform algorithm. An extensive introduction was prepared for Volume IV, Part A, Report No. EERL 72-100, where details of the methods used can be found together with examples of applications to various problems of earthquake engineering and strong-motion seismology. That introduction should also serve as a basic summary of background information for users of the data.

Contents of the Various Parts. The specific records whose "uncorrected" digitized versions appeared in Part A of Volume I are included subsequently with their analyses in Part A of Volume II, III, and IV. This arrangement has been maintained throughout the whole series. In Part C of Volume IV, Report No. EERL 73-101, we began the presentation of Fourier spectra analysis for the unusually important series of accelerograms obtained during the San Fernando

earthquake of February 9, 1971, and Part S contains the last of the San Fernando records. In Part T a return is made to those records received during the years 1933 to 1968, which continue into Parts U and V. Parts W and X contain the records from the Lytle Creek, California, earthquake of Sept. 12, 1970, and Part Y contains the records of the Borrego Mountain, California, earthquake of April 8, 1968, not already included in Parts A and B. Part Y marks the conclusion of the current digitizing and analysis project.

Component Directions. A description of the component direction nomenclature for the records was given in Volume II, Part B, Report No. EERL 72-50. Consistent with this, the component direction where it appears in this report refers to the direction of the transducer pendulum motion for the trace to be deflected "up" on the record when viewed in the normal way with time increasing from left to right. The direction of true ground acceleration is opposite to this pendulum motion. The spectral calculations of Volume IV, however, are concerned with the amplitude spectrum only and the particular component sense is thus immaterial.

Assessment of Long Period Errors. A separate section in Volume II, Part G, Report No. EERL 73-52, entitled "Current Assessment of Long Period Errors" describes the results of a recent investigation of long period displacements calculated from recorded accelerations. During the course of this study it became evident that the procedures for preparation of 70-mm and, to a lesser extent, 35-mm film records from the San Fernando earthquake of February 9, 1971, introduced spurious excitations at periods close to the duration

of the sectional enlargements. These effects have been removed from all of the 70- and 35-mm film records by filtering with a long period limit of 8 seconds rather than the standard cut-off period of 16 seconds in the Volume II correction procedure. The following list of Caltech reference numbers indicates the records from the San Fernando earthquake included in Volume I, Parts C through S, that have been processed with the cut-off period of 8 seconds:

Parts G, H, I, K, N, Q, R, S: All records in these parts.

Part J: Records J142 and J145 through J150.

Part L: Records L166, L167, L168; L172 through L175.

Part M: Records M176, M177, M178; M180 through M184.

Part O: Records O198 through O201; O206, O208, O210.

Part P: Records P231 and P232.

A decision was also made at the same time to eliminate a number of very low amplitude accelerograms from further processing (Volume II and on) reflecting the expectation that the resulting displacement records will be dominated by noise. Their Caltech reference numbers are as follows:

H127; I140; J151, J152; K153 through K156, K161 through K165; O202, O203, O209, O211, O212; P224 through P230.

Description of the Figures and Tables. For each component in the following pages the Fourier amplitude spectrum is presented in two forms - a linear plot and a log-log plot. Details concerning identification are given at the top of each plot. The second line gives the name, date, and time of occurrence of the earthquake; the third

line is comprised of two labels, the observation station and the component processed. The Roman numeral "IV" in the first identification label indicates that the results pertain to the fourth stage of data processing, i.e., Volume IV of Fourier spectra of accelerogram records already corrected for baseline adjustment and instrument response. The letter following the Roman numerals indicates the part of Volume II to which the processed record belongs. The three-digit number completing the first label is the Caltech Reference Number for the given earthquake record in Volume I, right-adjusted in a three-digit numerical field. The second label is a string of three numbers separated by periods; the first number gives the year in which the earthquake occurred; the second is the serial number of the record as it was received at the Caltech Earthquake Engineering Research Laboratory during that year; and the last number indicates whether it was a main event or an aftershock (sequentially numbered, the main event starting from zero). On the linear spectrum plot, the data lying above the 95 percent confidence level may be considered relevant to that degree. The spectra have been plotted up to a frequency of 25 cyc/sec on linear and logarithmic scales, corresponding to the capabilities of the instrumentation and data processing methods used.

Frequency Transfer Functions. This report presents many spectra of accelerograms recorded simultaneously at different locations in the same structure, for example, the basement, mid-height, and roof levels of a tall building. At present, it is planned to calculate frequency transfer functions involving smoothing and calculating the ratio of two such spectra in supplementary reports.

Acknowledgments. The cooperative efforts of many people are essential in the preparation of a series of reports of this kind and we have been fortunate in the quality of staff that has carried out the various details with special care and attention. We should like to express our appreciation to Mr. Vincent Lee for his assistance with many details of computer programming, to Miss Barbara Turner and Miss Sharon Vedrode for the care taken over typing and editing, to the staff of the Willis H. Booth Computing Center for their continued help with all aspects of the computing process, and to the staff of the Caltech Graphic Arts Facilities for very efficient work on publication details. The whole project has been made possible by the continued support of the National Science Foundation, supplemented in an important way by contributions from the Earthquake Research Affiliates Program of the California Institute of Technology.

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HIGH FREQUENCY AMPLITUDE ERRORS IN DIGITIZED STRONG MOTION ACCELEROGRAMS

The strong motion accelerograms generated by the San Fernando, California, earthquake provide an unprecedented opportunity to study high frequency ground motion, both because of the large number of accelerograms available for this earthquake and because of the favorable instrumental response in the frequency band of interest. We are currently studying the excitation and propagation characteristics of Fourier amplitudes of acceleration at 0.5, 1.0, 2.0, 4.0, 8.0, and 16.0 Hz for 95 San Fernando earthquake accelerograms, utilizing the data presented in Volume IV of the series "Strong Motion Earthquake Accelerograms" prepared by the Earthquake Engineering Research Laboratory of the California Institute of Technology.

In the course of our investigation, we have encountered high frequency noise generated by the digitizing process. Quite generally, this digitizing noise can affect the amplitudes in much of the high frequency band, which we loosely consider to be several to 25 Hz, 25 Hz being the maximum resolvable frequency with the existing routine processing techniques (Trifunac et al, 1973). In view of the potential significance that such noise may have on both seismological and engineering analyses of high frequency Fourier amplitudes of acceleration, we report separately here our present assessment of this problem.

The amplitude errors applicable to the series "Strong Motion Earthquake Accelerograms" have been described by Trifunac et al (1973). Five "accelerogram" data sets were derived from five

independent digitizations of the same straight line; the mean of the data sets serves as a baseline with which to correct the five data sets for systematic errors of the digitizing machine. The remaining error was a nearly normally distributed random error with a standard deviation of one digital point ($\frac{1}{312}$ cm).

The straight line length was 60 cm, and the experiment was designed to represent a 30-second AR-240 accelerogram, recorded on 12-inch wide paper and digitized without enlargement. In fact, the length of the experimental line in centimeters has no intrinsic physical significance; it is only its length in seconds, defined relative to the actual accelerogram of interest, that is important. For the estimation of high frequency noise, this length-to-time conversion is fixed by the necessity of having the sampling rate in pts/sec for the actual accelerogram equal to the sampling rate in pts/sec for the experimental line. The estimate of high frequency noise in the actual accelerogram, of course, will depend in addition on any difference between the length in seconds of the actual accelerogram and the normalized length in seconds of the experimental line.

In our investigation of high frequency ground motion, we have used a 15-second sample of data beginning with the direct shear arrival. Because the routine digitizing process employs variable sampling rates, the determination of an average sampling rate is somewhat arbitrary. The noise estimates given below and in Figure 1 are based on a sampling rate of 56 points/sec. This value corresponds to a point spacing of 0.018 seconds, which is the average of four median values determined from cumulative frequency distributions of

successive points in the first 20 seconds of four accelerograms for which digitizing noise is dominant at 16 Hz. These distributions are displayed in Figure 3, and we shall return to them and the influence of the variable sampling rate scheme at the conclusion of this correspondence. The 60 cm experimental line length was digitized with approximately 1,000 points (Trifunac et al, 1973) and when considered to be digitized at 56 pts/sec corresponds to an 18-second blank accelerogram. We consider the noise estimates of this 18-second blank to be an adequate measure of the expected noise in the 15-second sample of acceleration data.

The Fourier amplitude of the random error obtained in the analysis of the experimental line are plotted against frequency in radians per centimeter of line length in Figure 7 of Trifunac et al (1973). For a line length-time conversion of 3.3 cm/sec and a data sensitivity of 7.6 cm/g, Figure 1 gives the expected digitizing noise range in Fourier amplitudes of acceleration for the frequency band 1-25 Hz to be expected from a 15-second accelerogram digitized at 56 pts/sec. A data sensitivity of 7.6 cm/g is that of an original AR-240 accelerogram and is also that of RFT-250 and SMA-1 accelerograms in the form to be digitized, that is, with a 4x photographic enlargement.

An observational encounter with the presence of high frequency noise is illustrated in Figure 2. Here the Fourier amplitude of acceleration at 16 Hz for the previously described 15-second sample of San Fernando accelerograms at sites south of the epicenter is plotted against epicentral distance (R). With considerable scatter,

the amplitude data fall off monotonically with R out to 60-70 km.

Beyond this distance, the amplitude data define a constant level independent of further increases in R, strongly suggesting the presence of noise. The solid curve is based on an amplitude decay law of $\frac{\tilde{a}_0}{R} e^{-\frac{\pi f R}{Q\beta}}$, with frequency $f = 16$ Hz, shear-wave velocity $\beta = 3.2$ km/sec, and quality factor $Q = 325$; \tilde{a}_0 is the appropriate amplitude scaling.

The expected noise levels are indicated by the hatched areas. Those for the AR-240, RFT-250, and SMA-1 accelerograms have been taken directly from Figure 1. That for the older "standard" accelerographs has been obtained with the appropriate difference in sensitivity between this instrument and 7.6 cm/g.

It is clear from Figure 2 that Fourier acceleration amplitudes at 16 Hz for the San Fernando earthquake are at the noise level for $R \geq 60$ km and, moreover, that the predominant source of this noise is random digitizing error corresponding to 1 digital unit. This latter result is the same as that obtained in similar comparative studies of long-period errors (Hanks, 1973, 1975; Trifunac and Lee, 1974). In the course of our investigation of Fourier amplitudes of acceleration for the San Fernando earthquake at 0.5, 1.0, 2.0, 4.0, 8.0, and 16.0 Hz, digitization noise was a factor only at 16 Hz. At 8 Hz, the data at distances out to 150 km are well above the noise level and describe a fairly well-defined decay with increasing R, in reasonable agreement with the same theoretical amplitude decay given in Figure 2.

Interestingly, Fourier amplitudes of acceleration at 16 Hz and $R \geq 60$ km are not significantly greater when the sample length includes the whole record. This apparent anomaly stems from the variable sampling rate with time on the accelerogram. Table 1 gives the mean sampling rate, the first 20 seconds median sampling rate, and record length in seconds for four accelerograms whose cumulative sampling interval counts in the first 20 seconds are displayed in Figure 3. The average sampling rate for the accelerograms at L171 and P220 is barely adequate to recover 16 Hz amplitudes uniformly throughout the record (whether signal or noise). Given that 20 seconds of these records are sampled at a rate considerably greater than the average rate, it follows that much of the remainder of these records are sampled at a rate less than the 32^+ points/sec necessary to recover 16 Hz amplitudes. In short, the sampling rate elsewhere in these two records is not sufficient to generate the otherwise expected digitizing noise at 16 Hz.

For the accelerograms at sites N191 and O206, the average sampling rate is substantially above 32^+ pts/sec, and, indeed, whole record spectral amplitudes at 16 Hz are somewhat greater than the 15-second sample spectral amplitudes, although not so large as would be expected on the basis of their record length alone. Even in these cases, Table 1 indicates that significant fractions of these records were probably not sampled at 32^+ pts/sec.

The variable sampling rate is related to the signal character as a function of time. High amplitude, high frequency samples, such as those accompanying the main energy group, deserve and clearly

get more dense sampling than lower amplitude, lower frequency signals of the coda. This process is nearly optimal for recovering observable signal at high frequencies, while at the same time not generating noise continuously throughout the record. On the other hand, true noise estimates are thus dependent on the extent of record digitized at or above a certain sampling rate, and some care must be exercised in its determination.

We feel that Figure 1 is generally representative of the high frequency digitizing noise to be expected in the bulk of the San Fernando accelerograms. In view of the actual variations in record length and median sample rate for these records, as well as the variations of sampling rate within these accelerograms, it also seems clear, however, that Figure 1 should not be taken too literally, unless careful attention is paid to these parameters in the particular accelerogram of interest. We recommend that signal amplitudes less than a factor of two greater than the upper limit of noise in Figure 1 be regarded as processing-generated noise. With these considerations in mind and with an additional allowance for other data sensitivities, Figure 1 may be taken as generally representative of the high frequency digitizing noise to be expected for accelerograms of the series "Strong Motion Earthquake Accelerograms."

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- Trifunac, M. D. and V. W. Lee (1974). A note on the accuracy of computed displacements from strong-motion accelerographs, Bull. Seism. Soc. Amer., 64, 1209-1219.

Table 1

Accelerograph Site ¹	Sampling Rate		Sampling Rate		Record Length
	Whole	Record Average	First 20 Seconds ²		
	pts/sec		pts/sec		sec
L171	35.5		47.6		52.5
N191	47.5		66.7		70.2
O206	47.5		66.7		52.8
P220	39.3		47.6		60.9

¹ "Strong Motion Earthquake Accelerograms" identification number.

² Median value

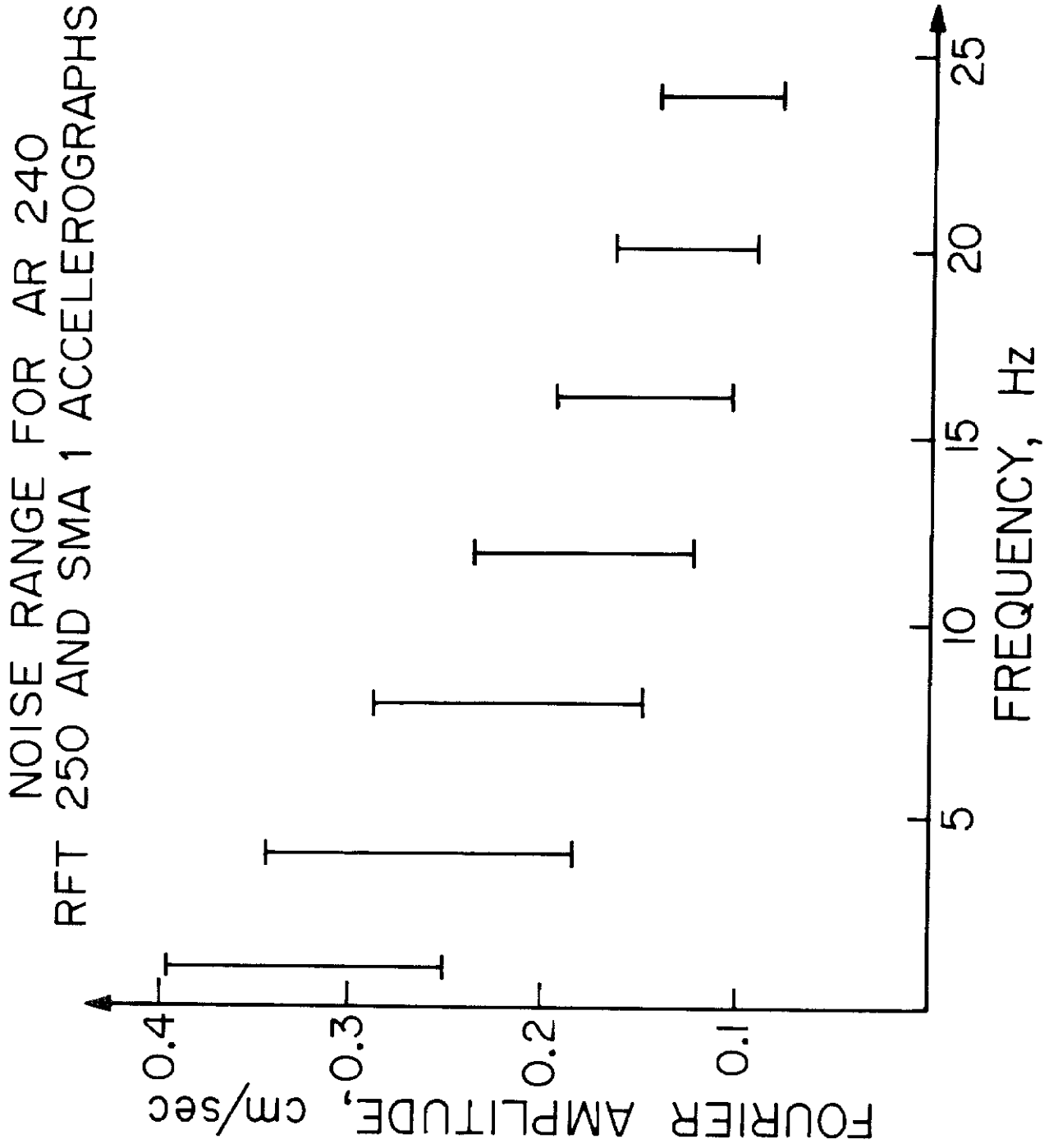


Figure 1

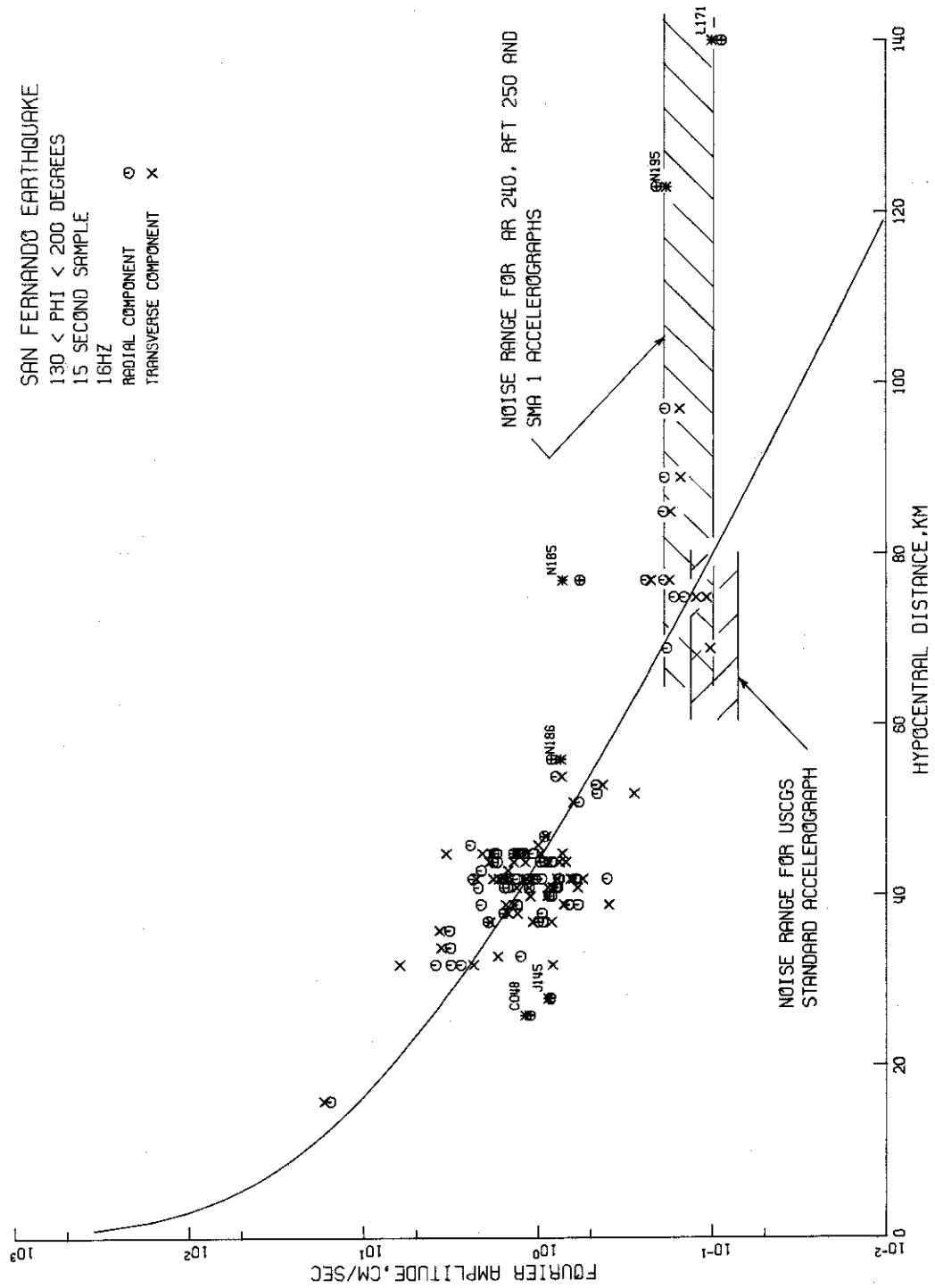


Figure 2

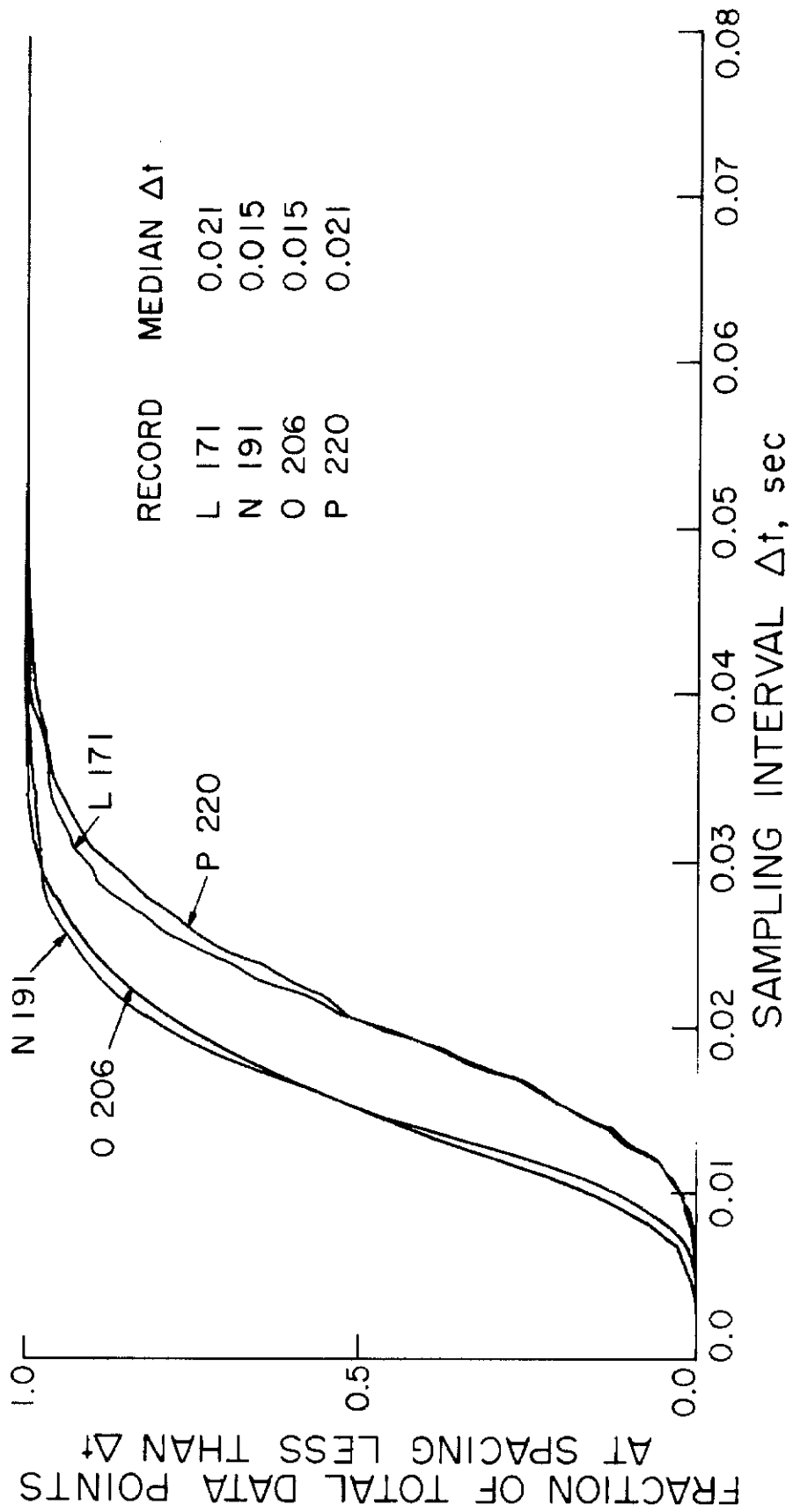


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EARTHQUAKE DATA

The San Fernando, California, Earthquake of February 9, 1971,
0600 PST; epicenter, $34^{\circ}24.7'N$, $118^{\circ}24.0'W$;* maximum intensity, XI;
revised magnitude (M_L), 6.4; depth, 13.0 km.

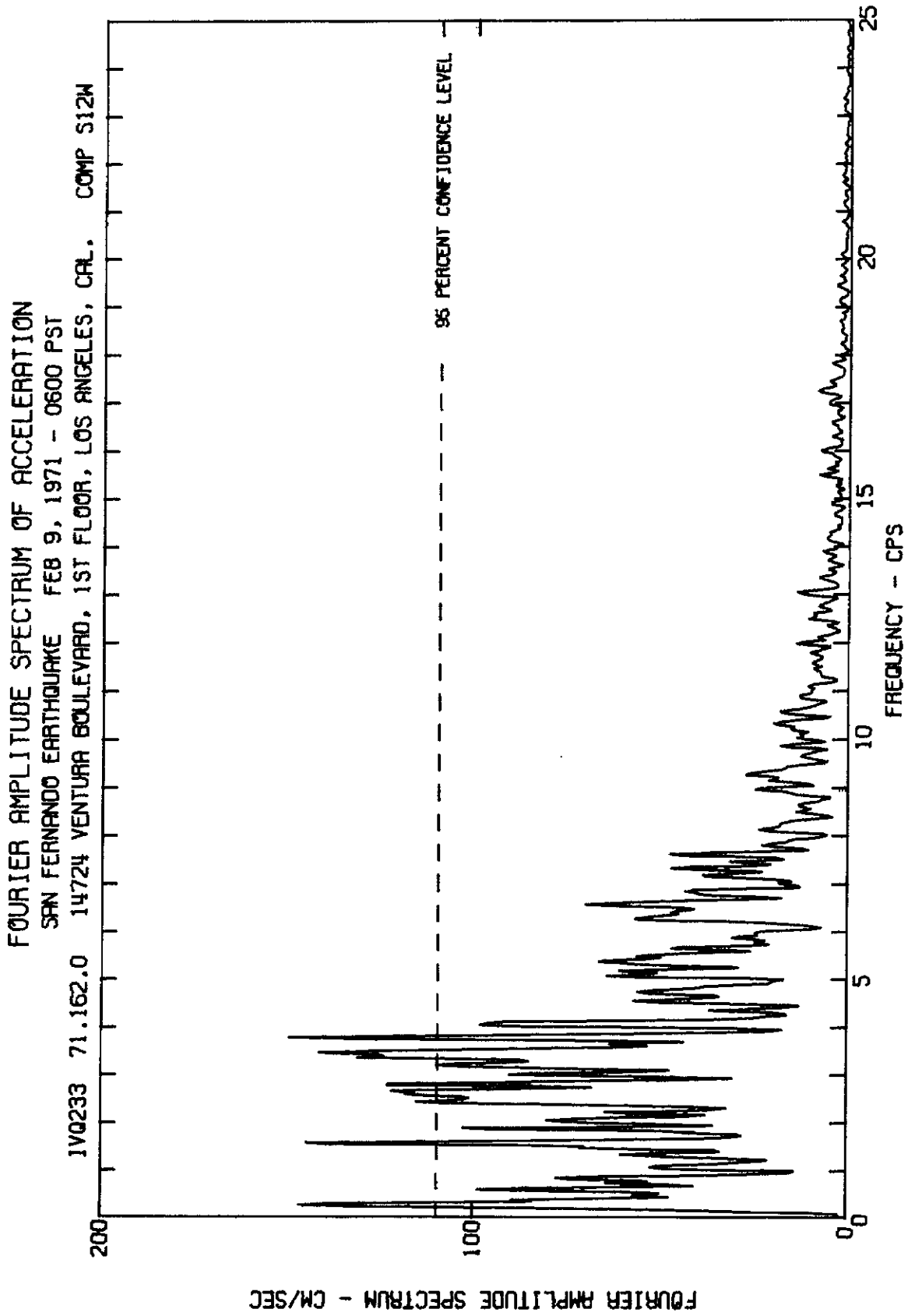
*Latest revised epicenter location.

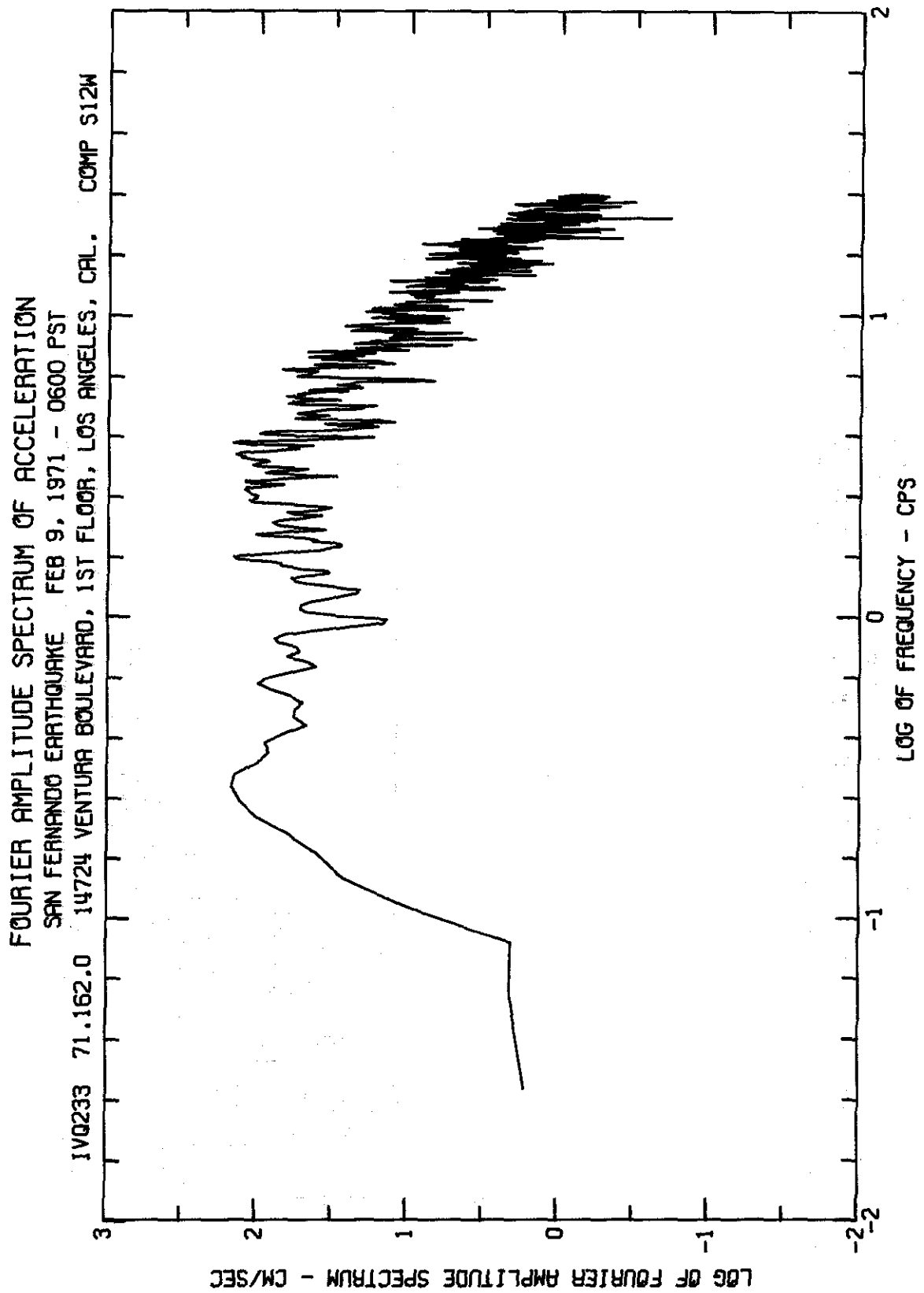
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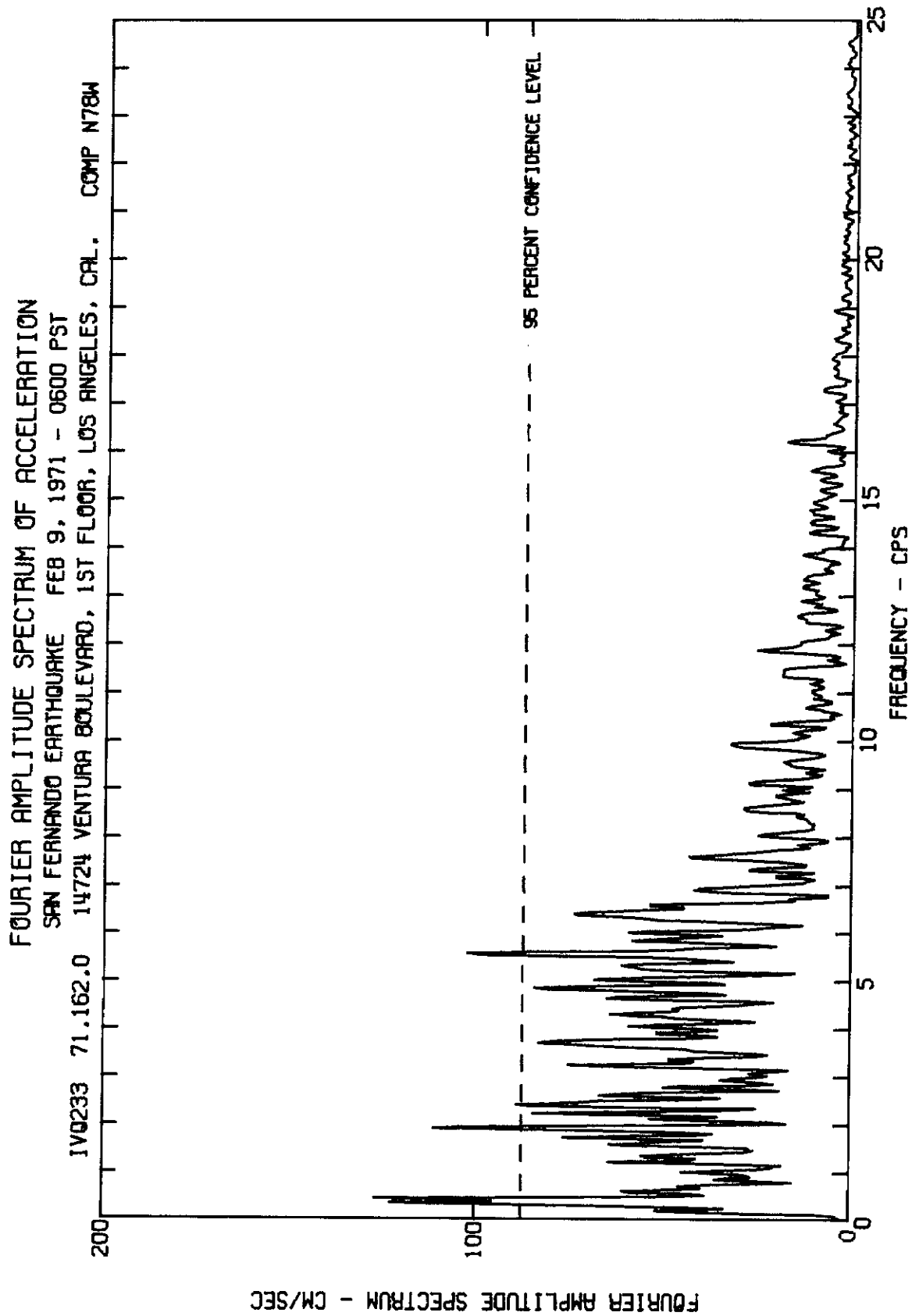
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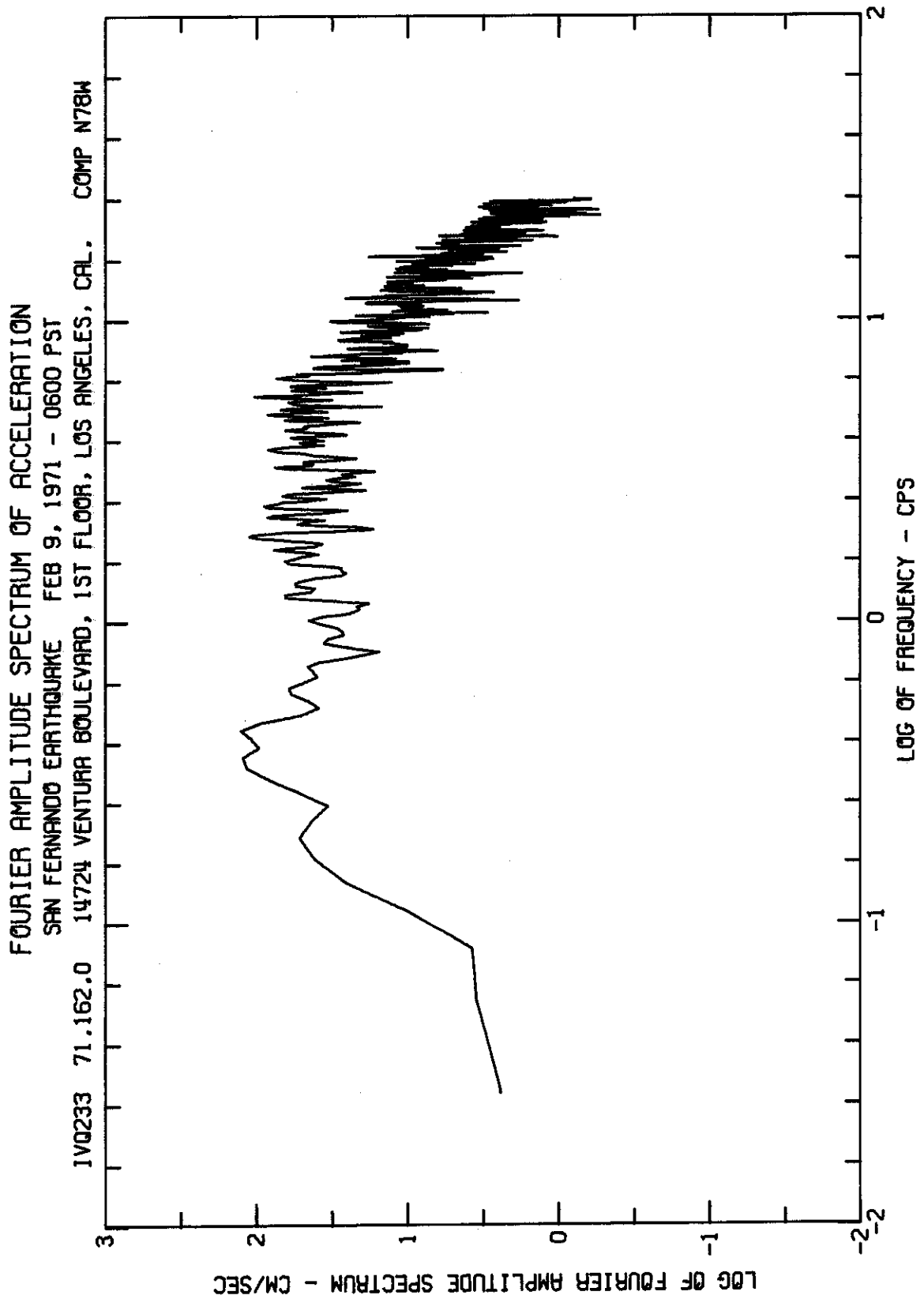
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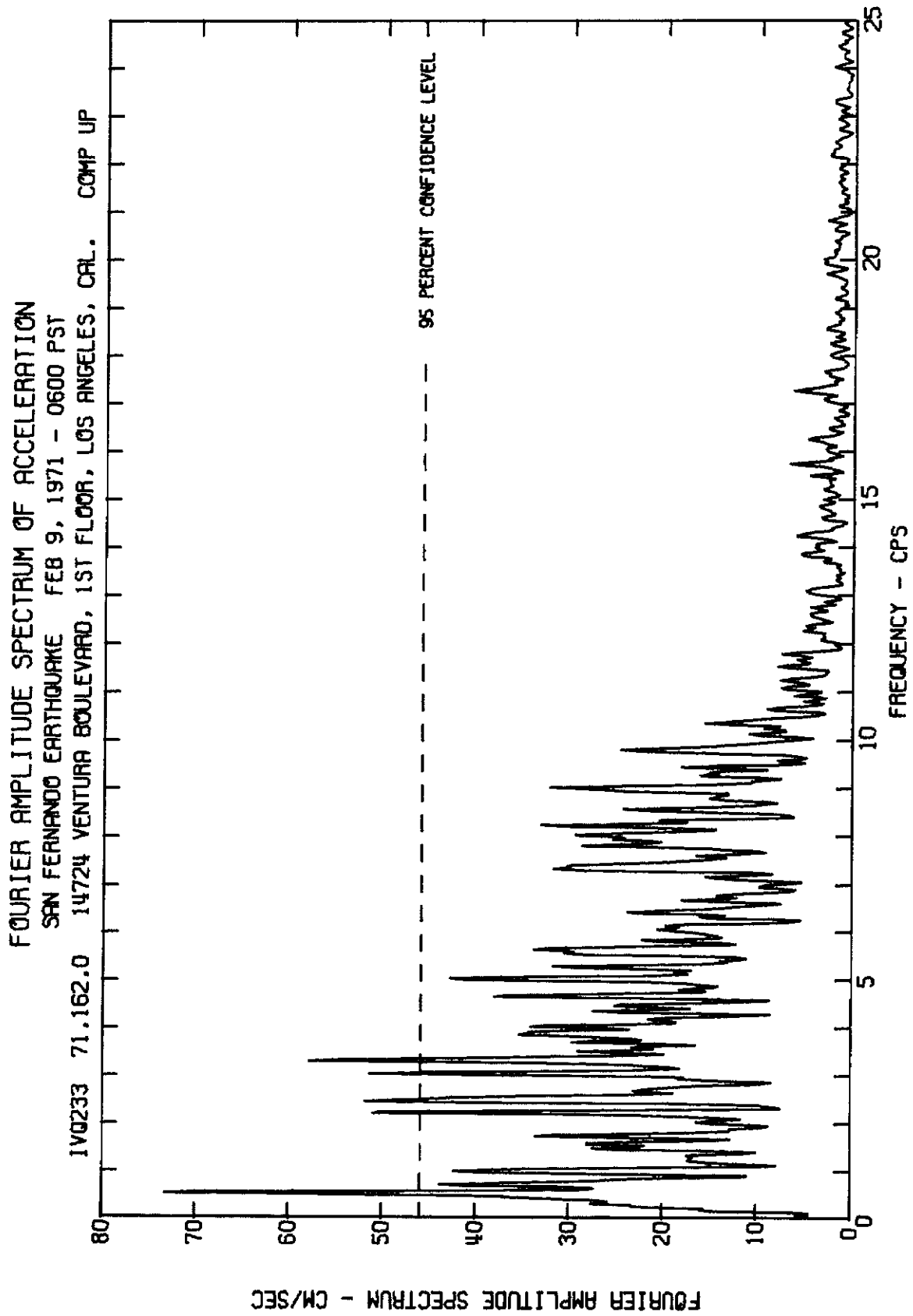
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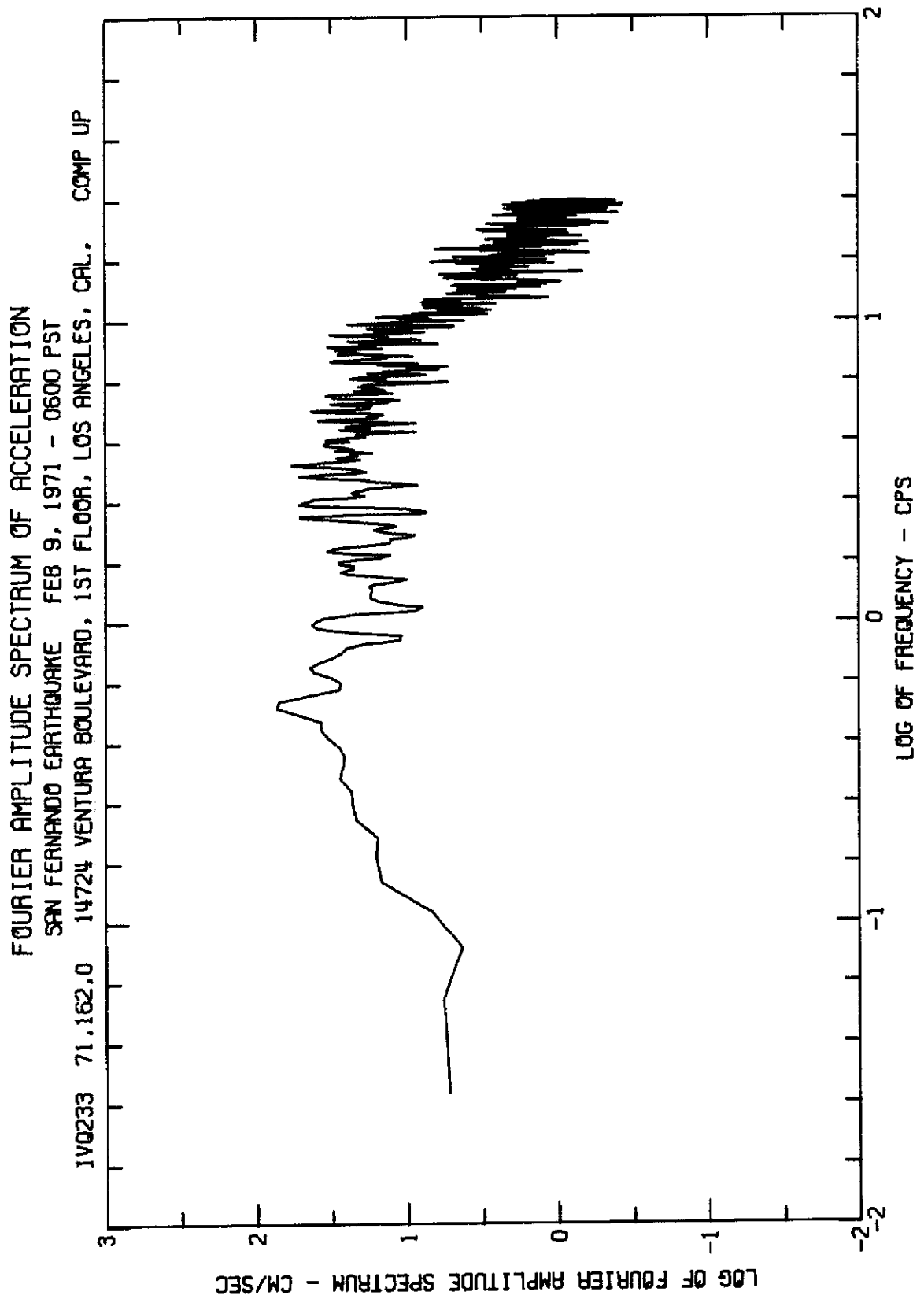


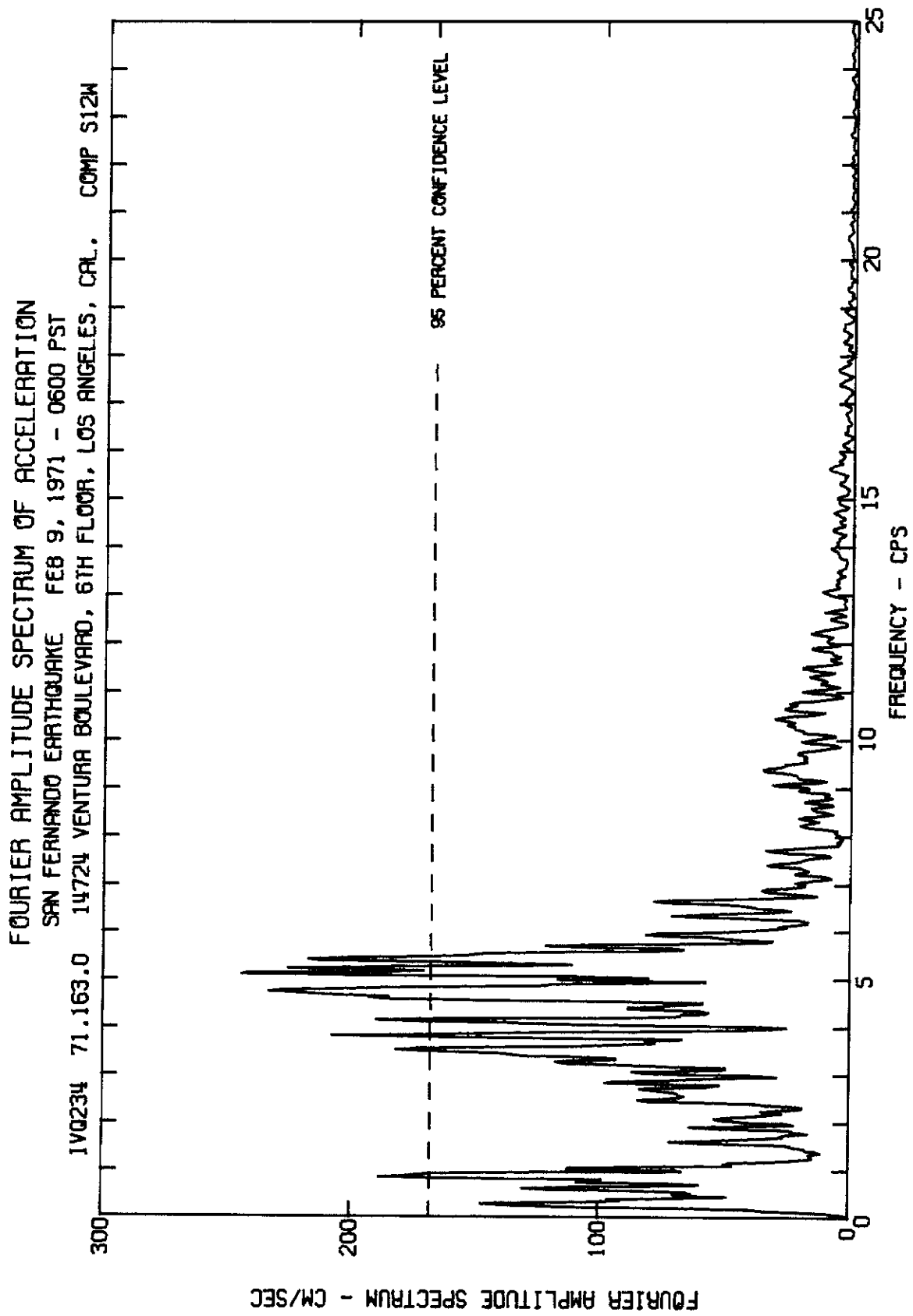


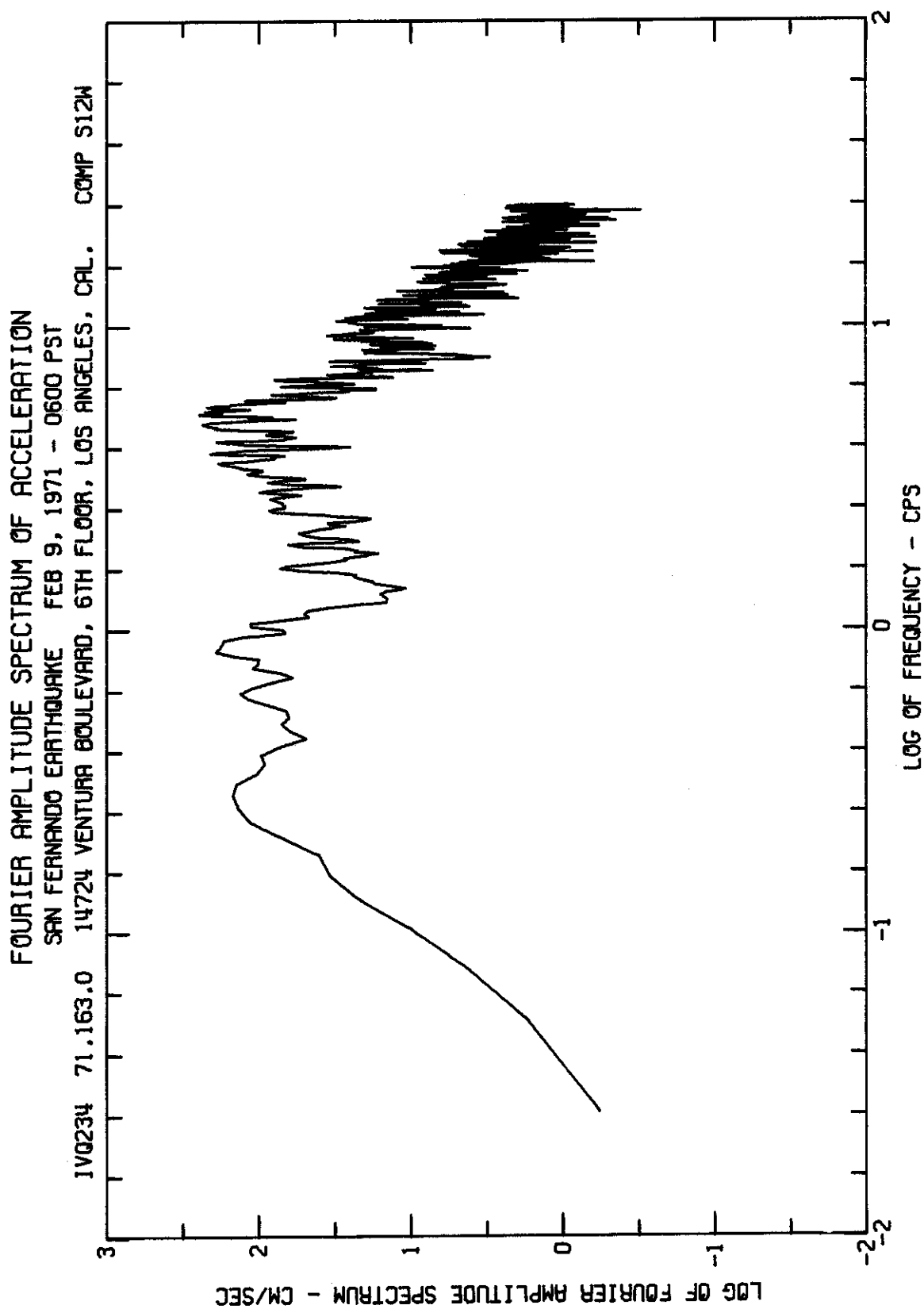


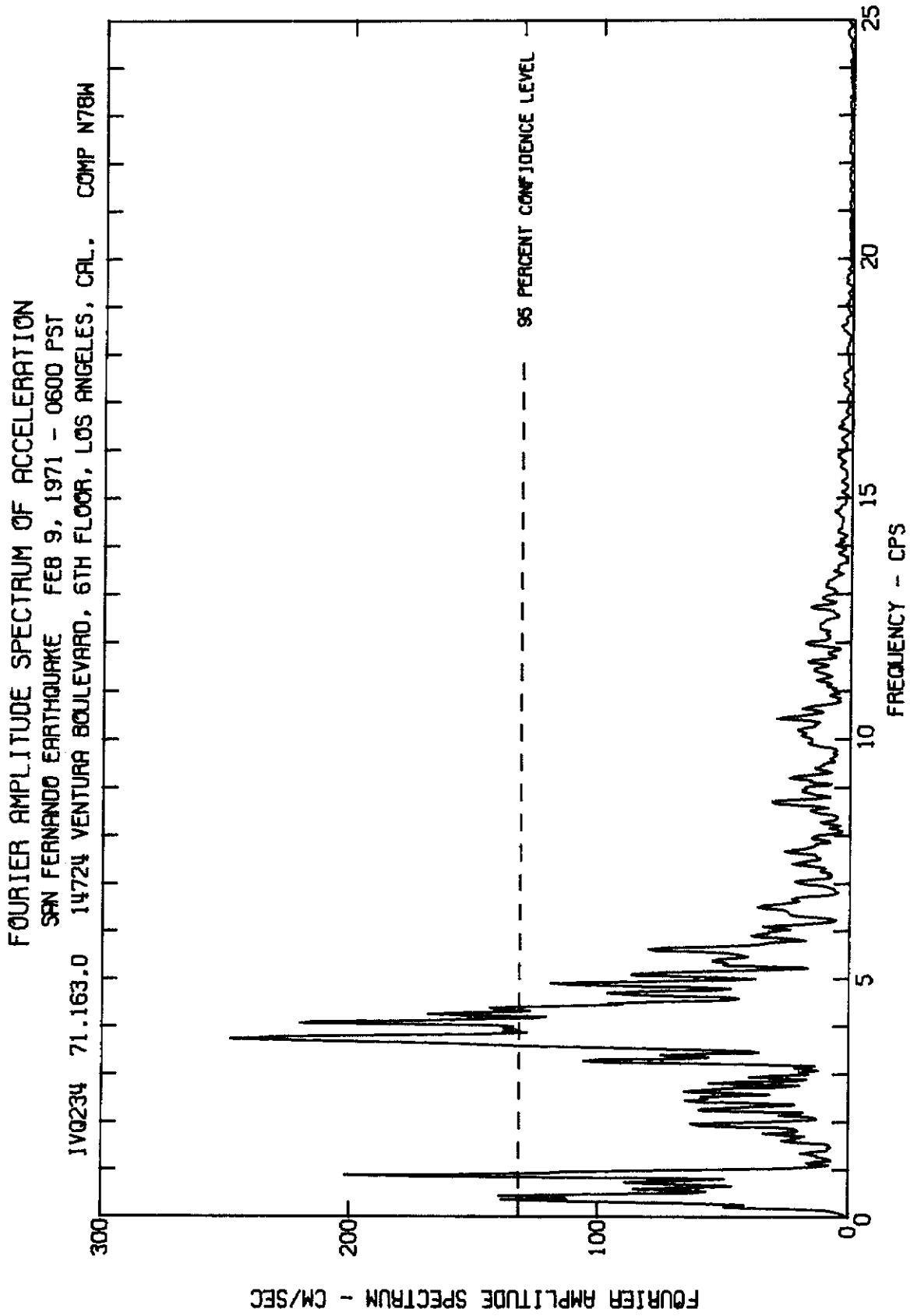


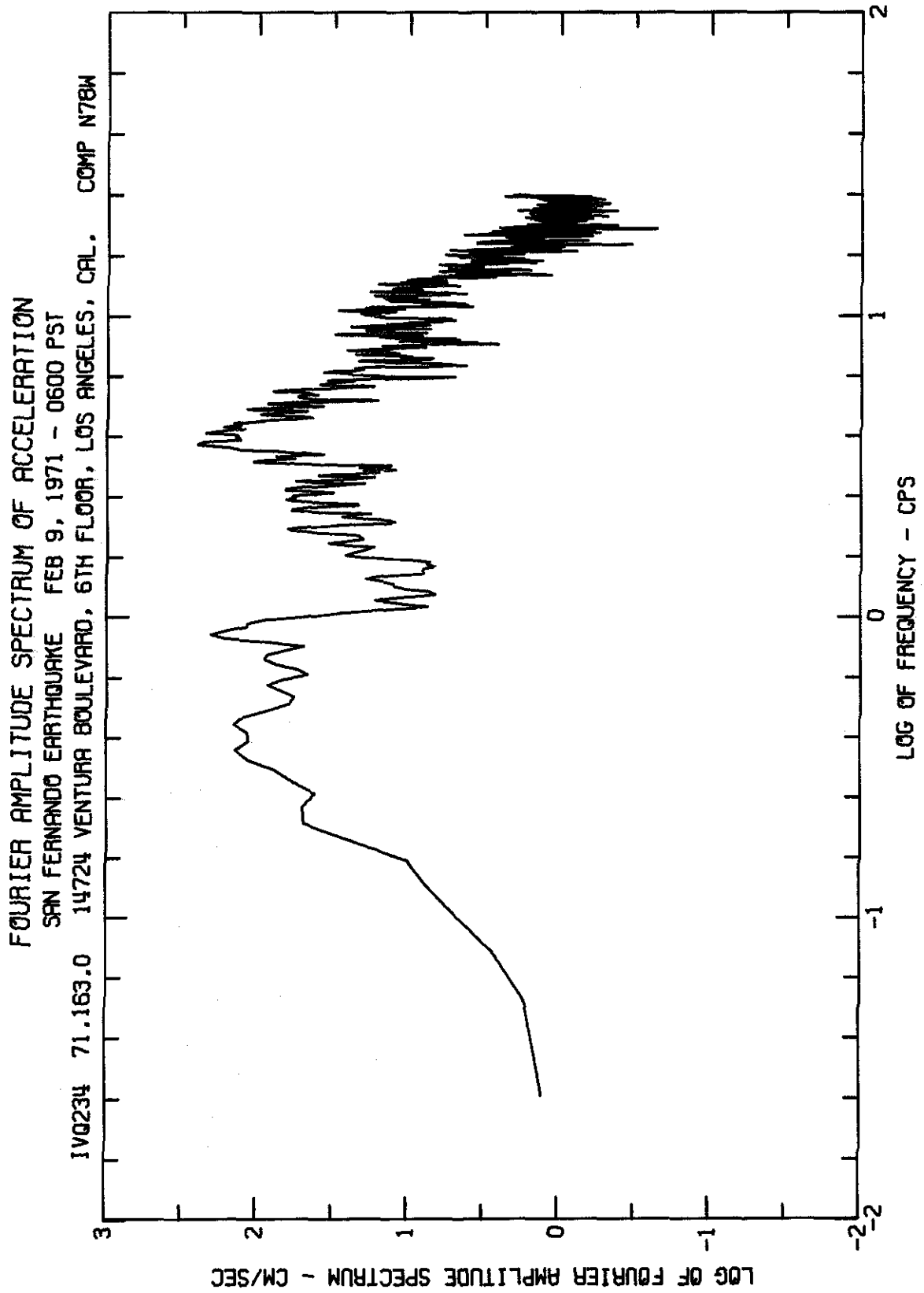


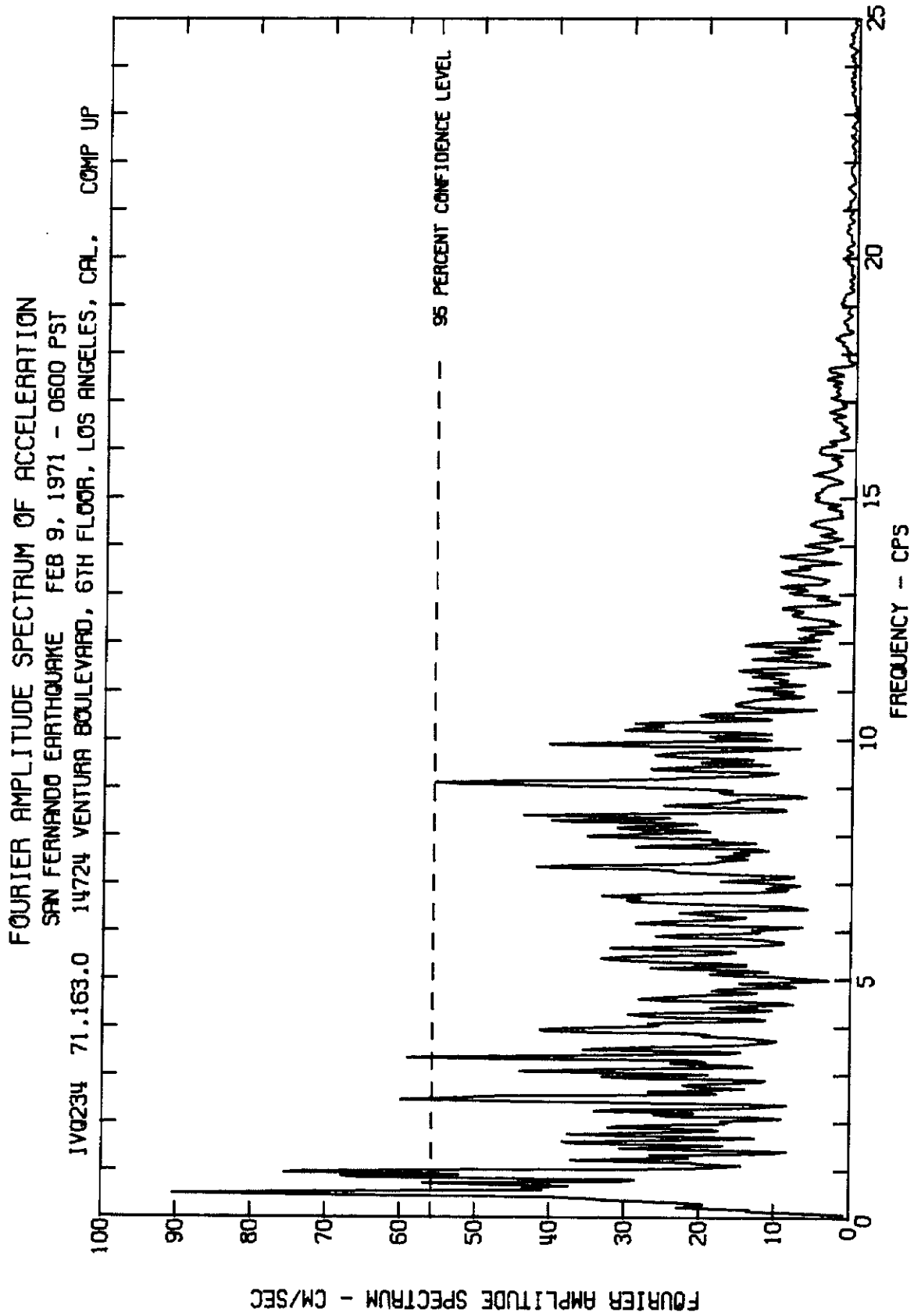


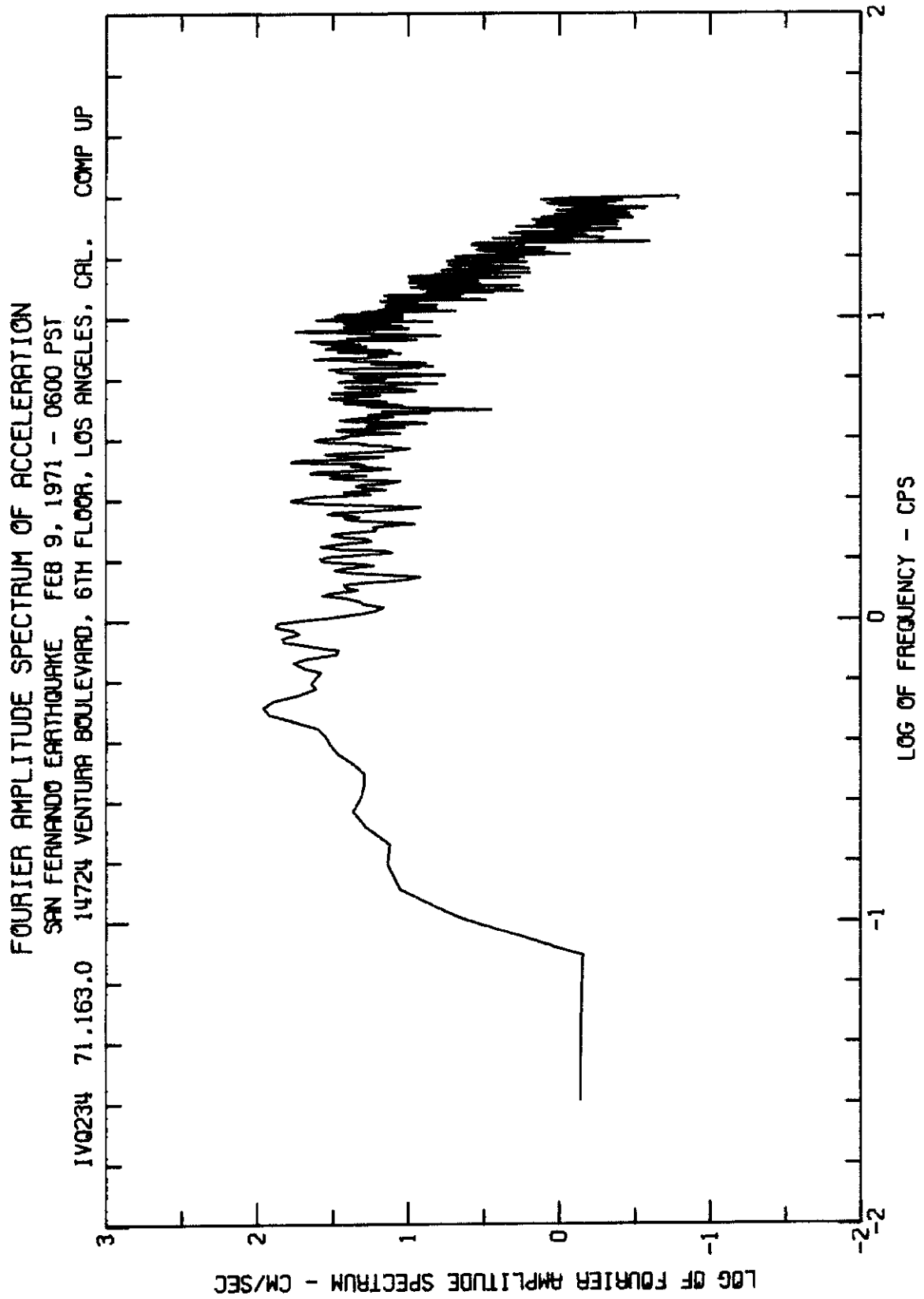








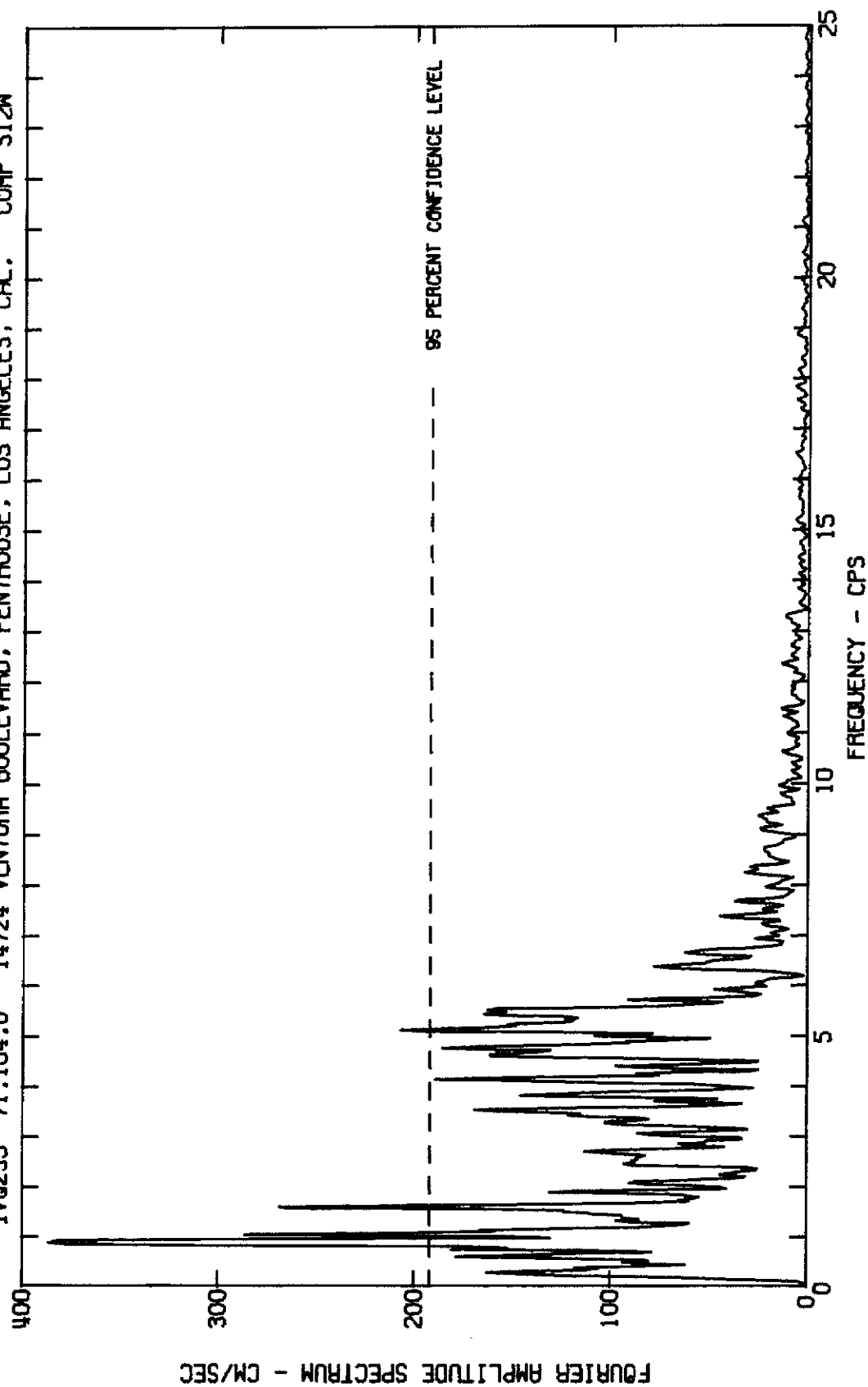


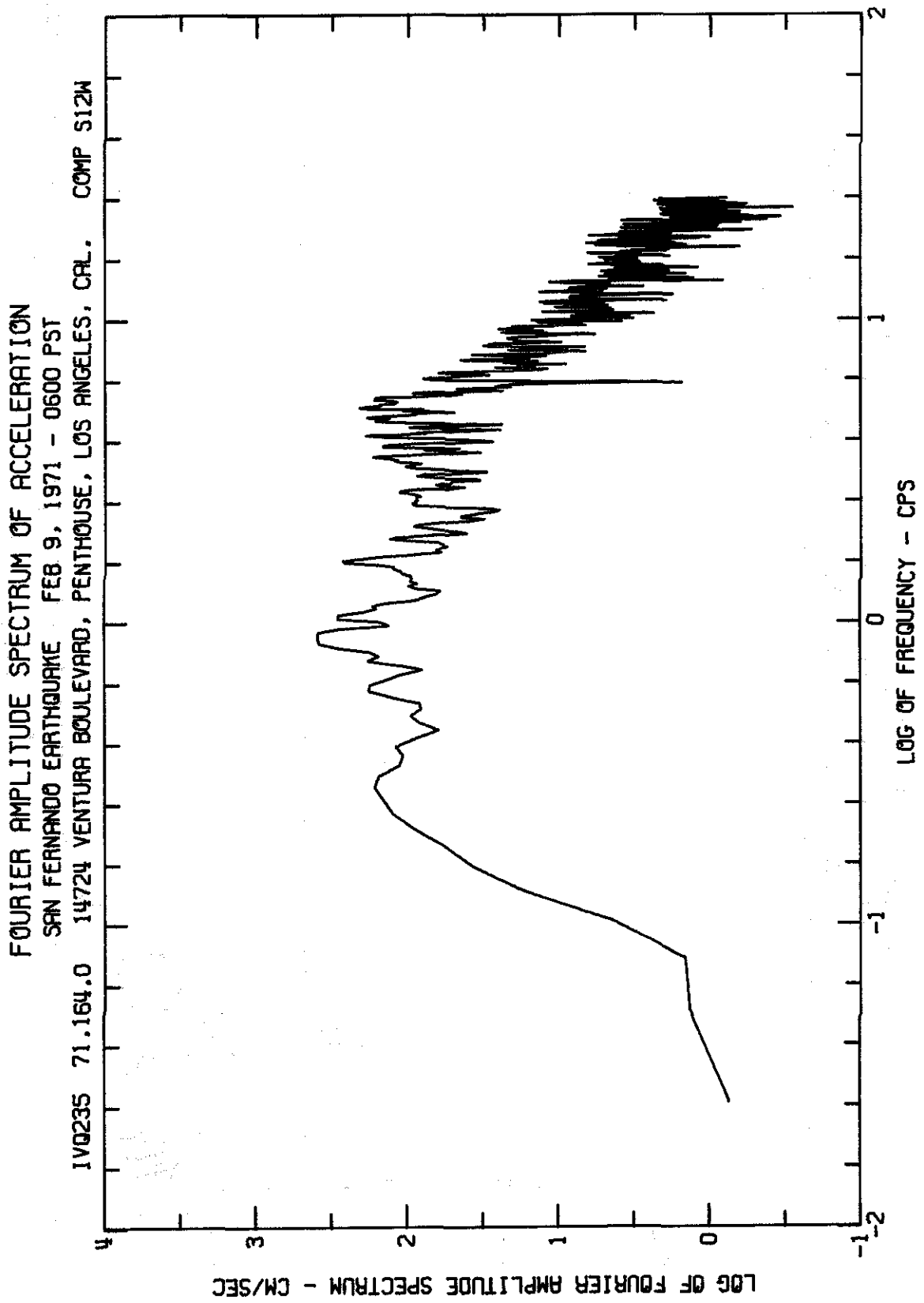


FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

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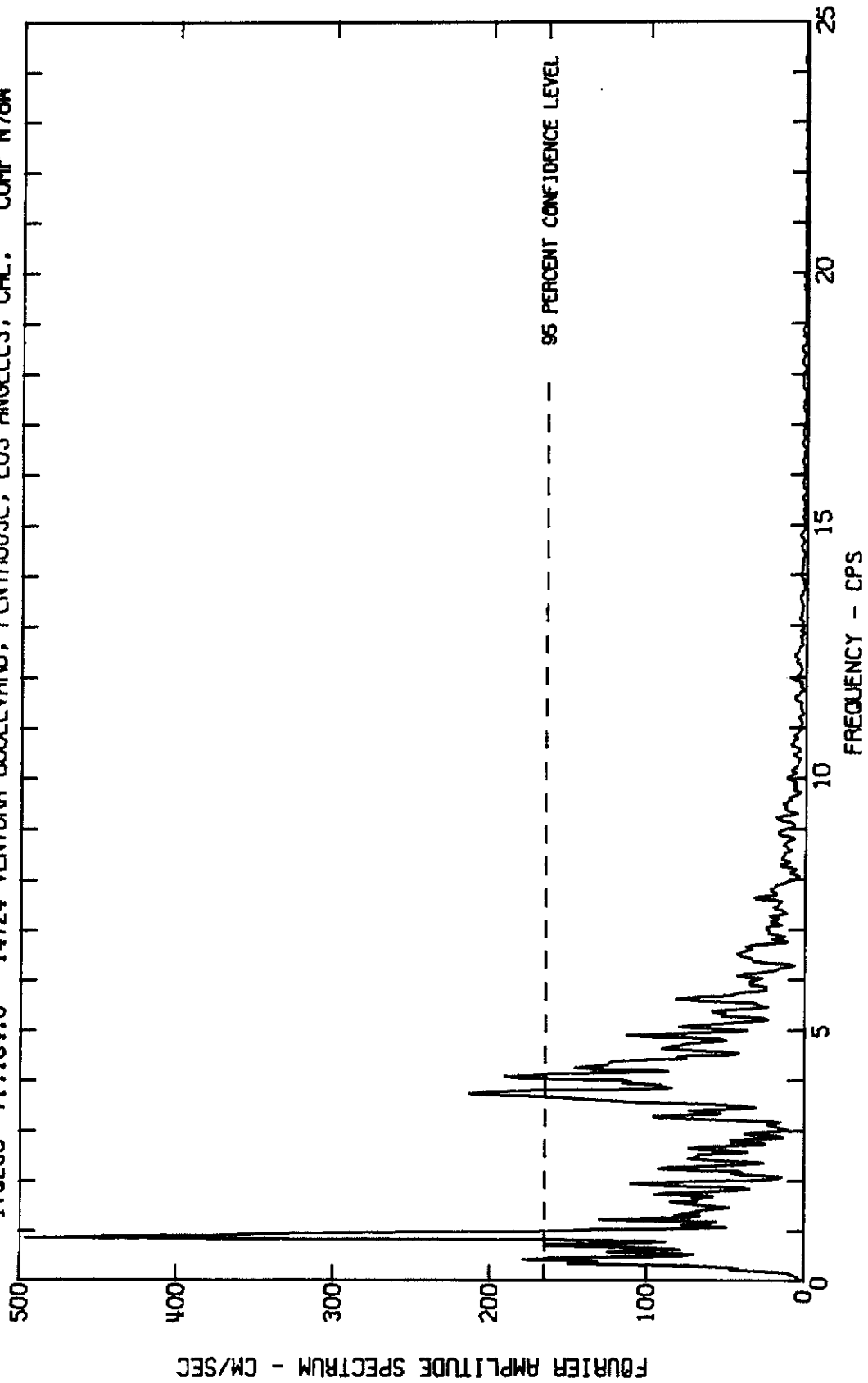


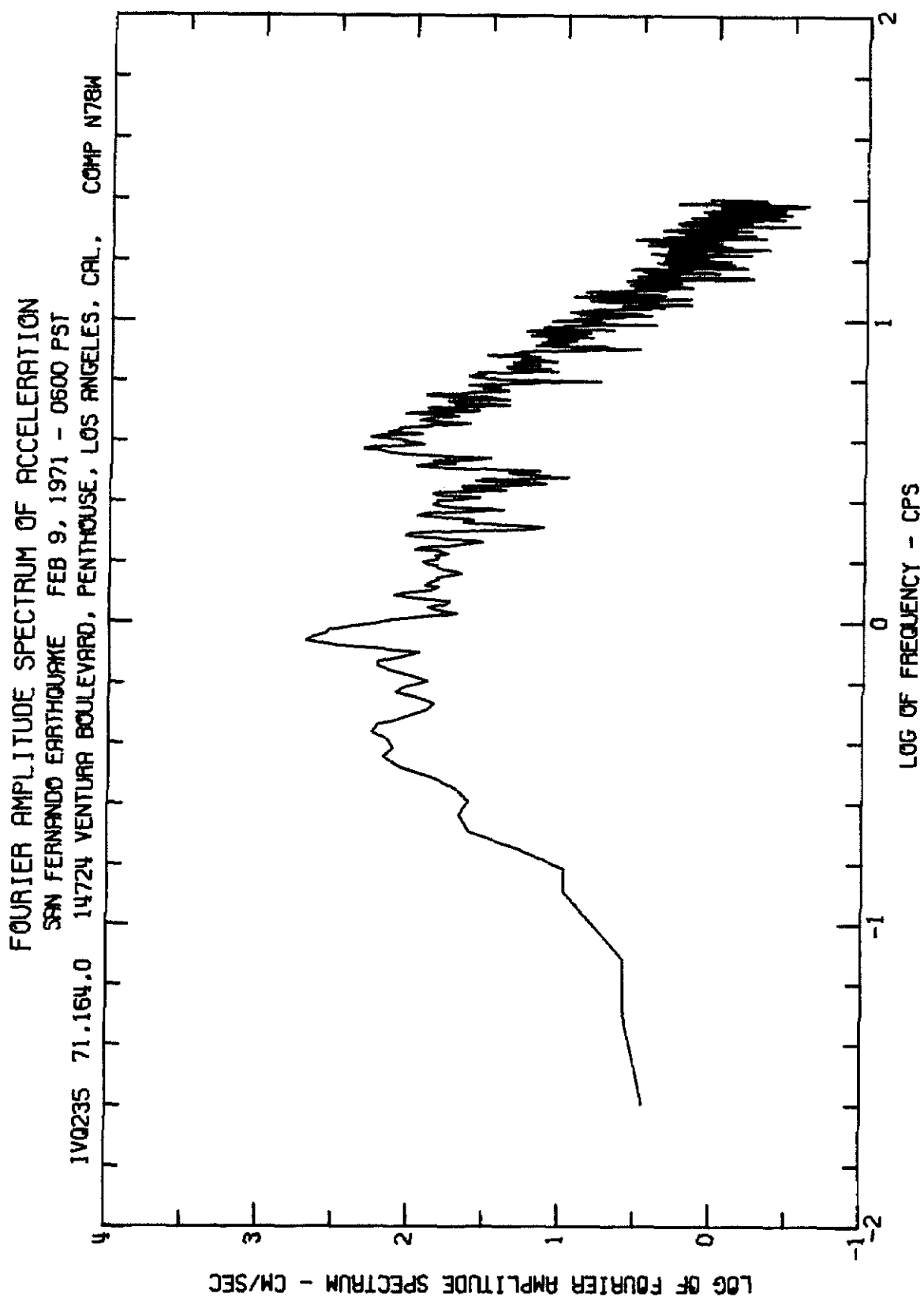


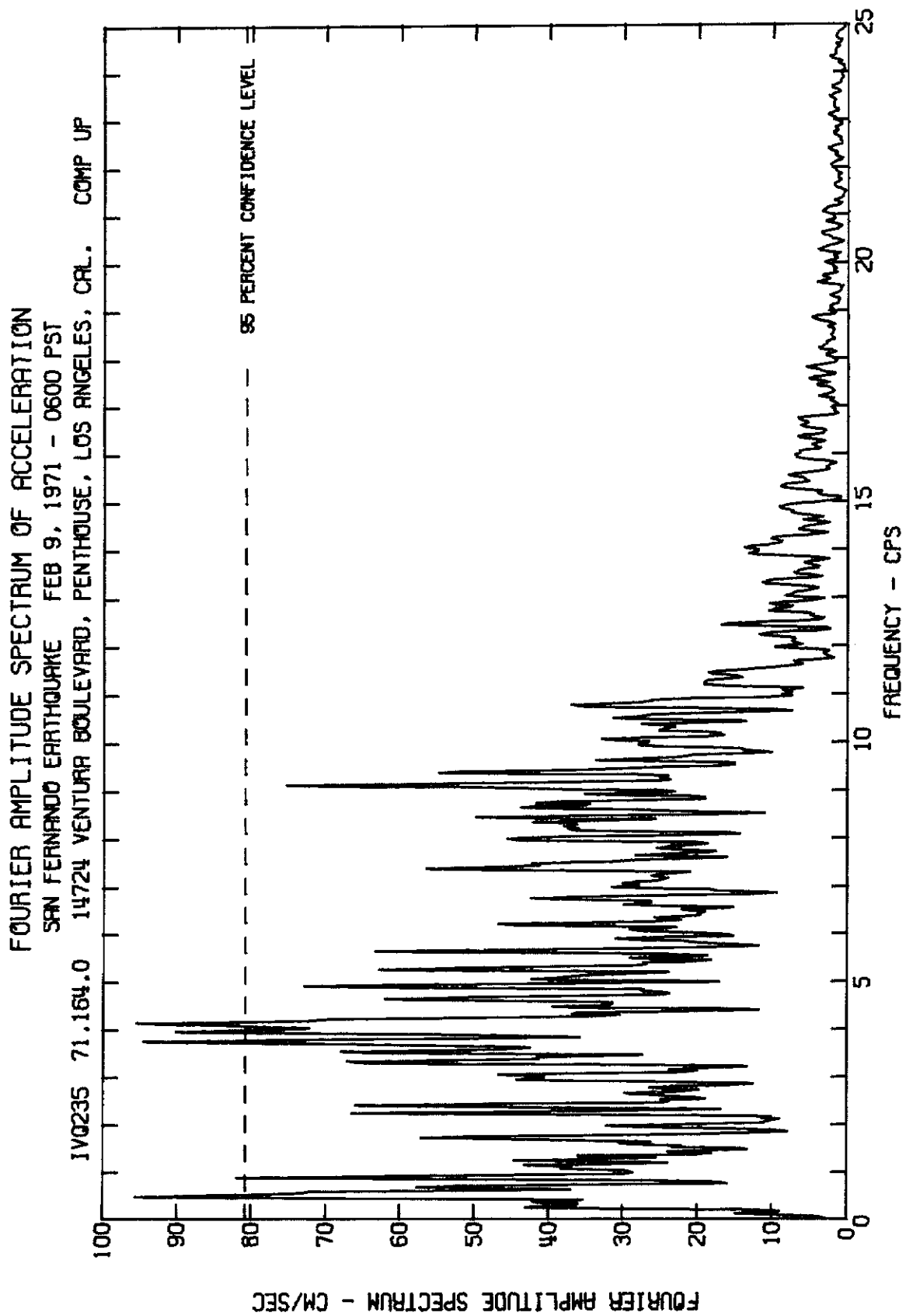
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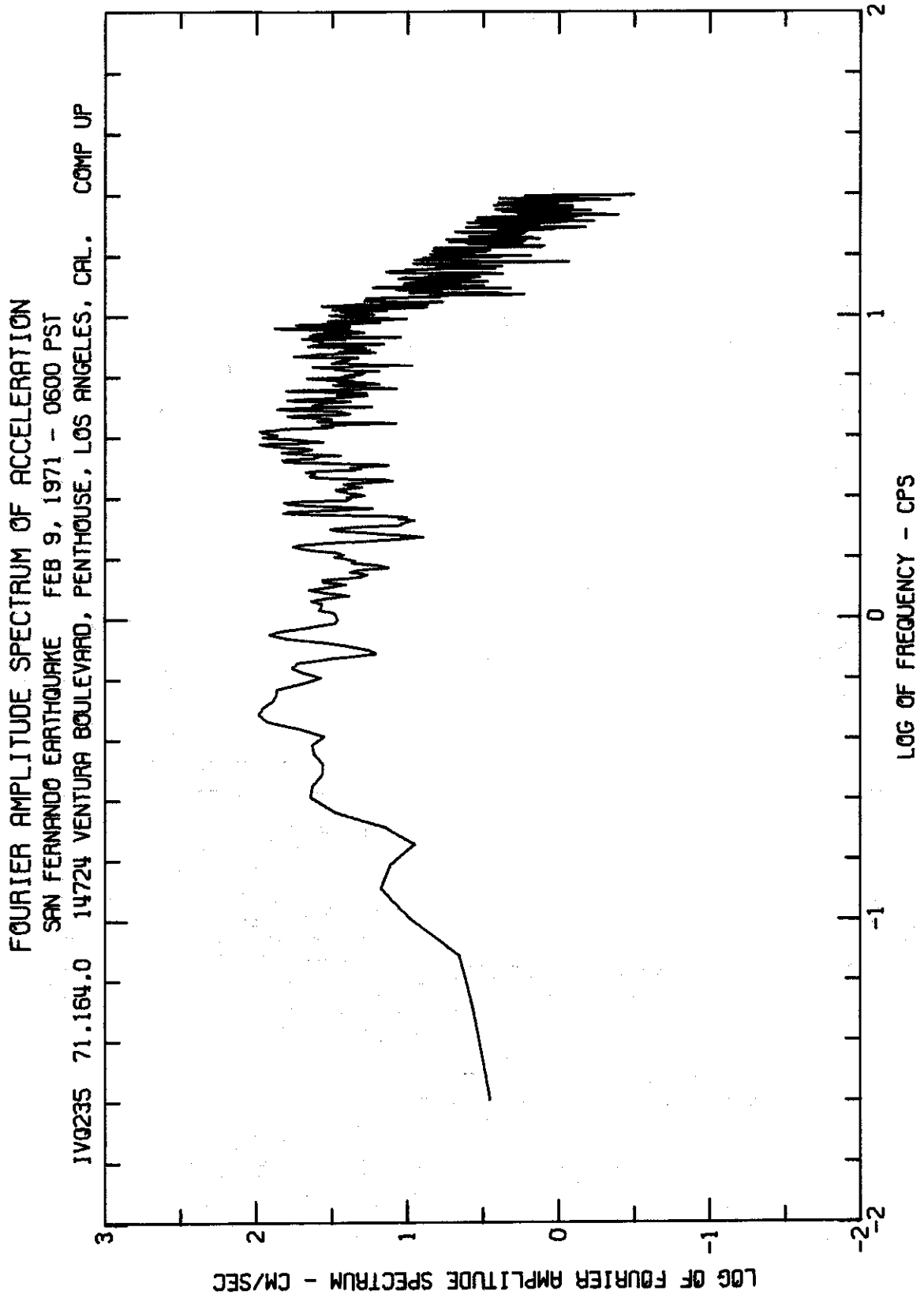
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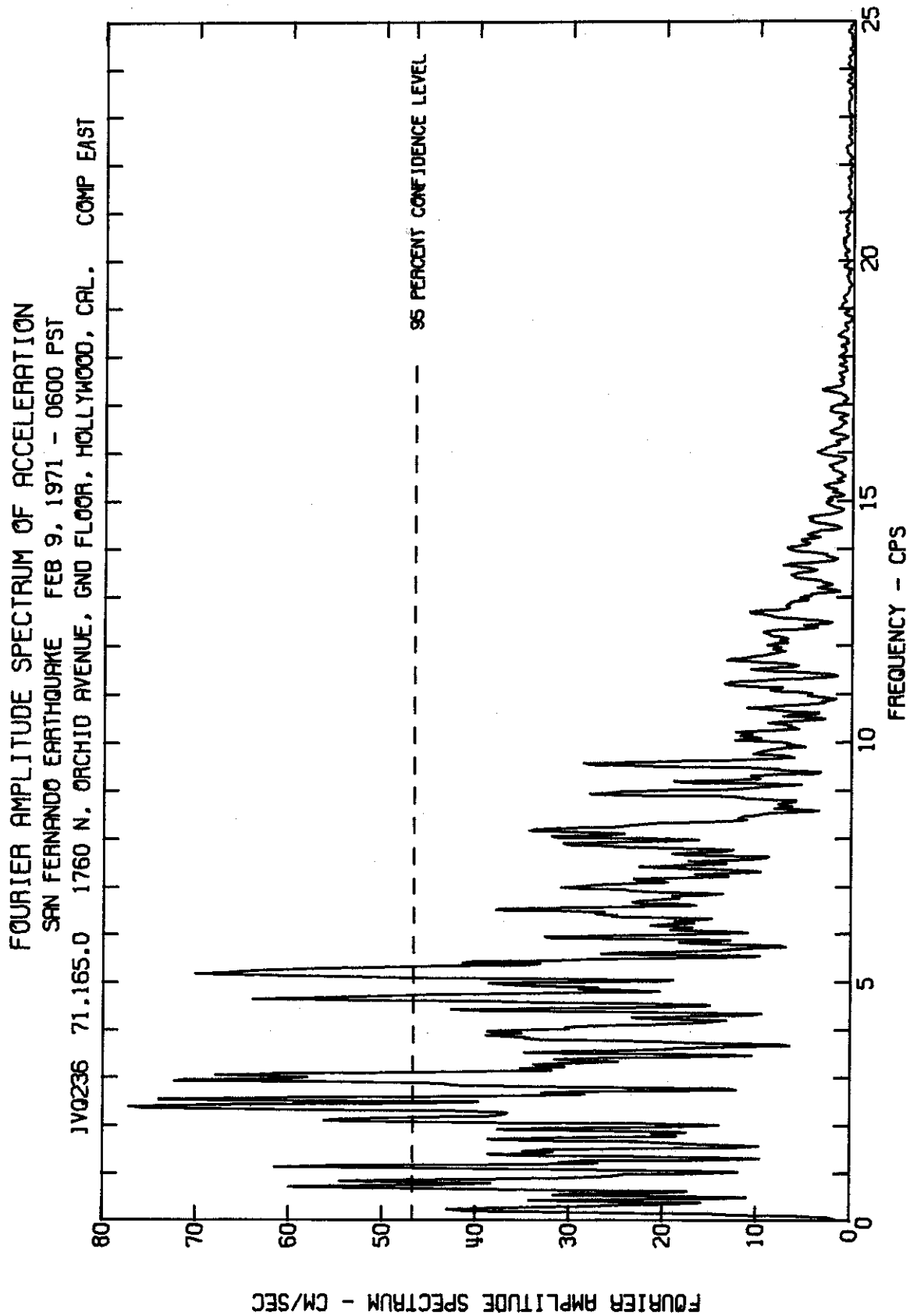
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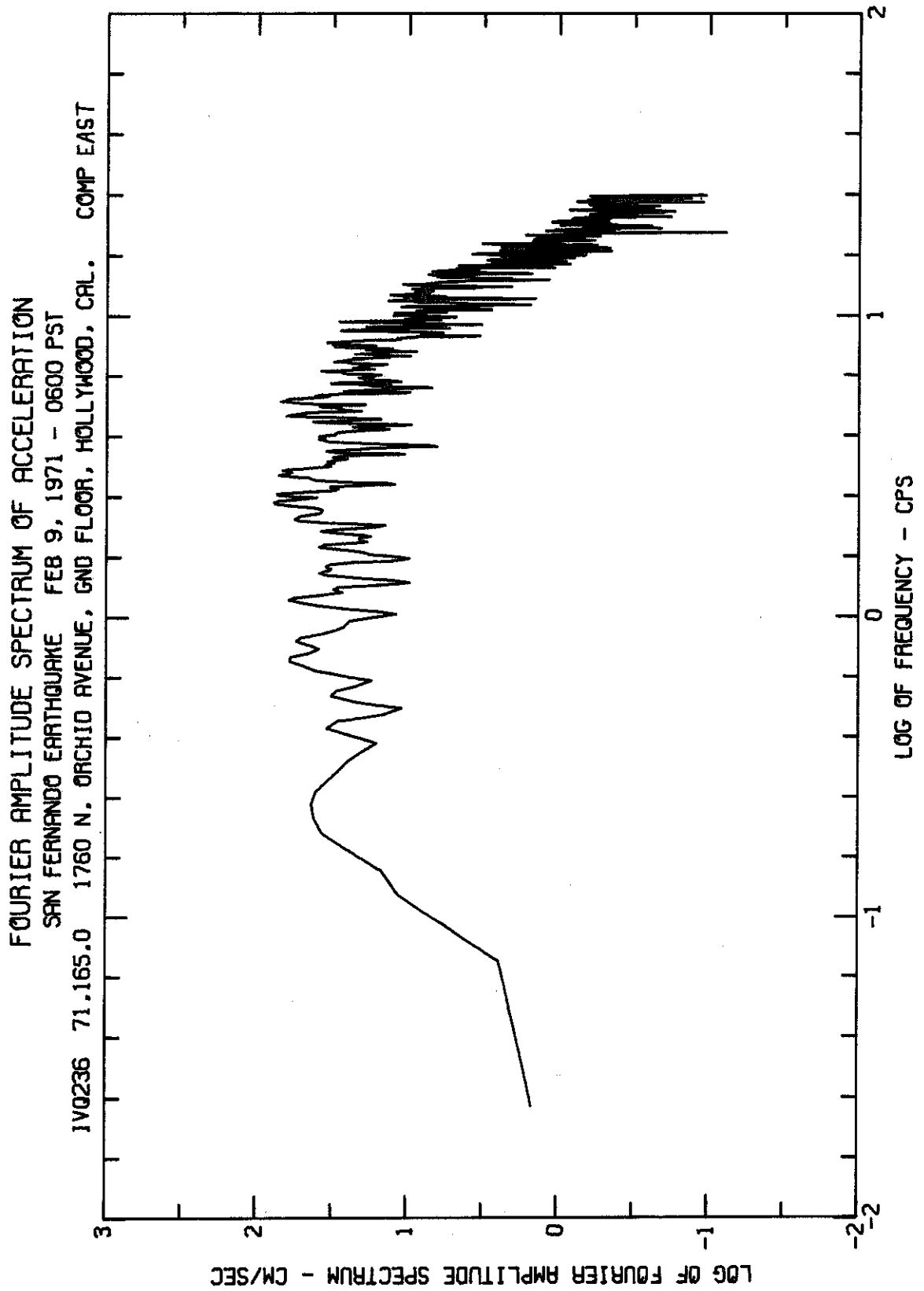


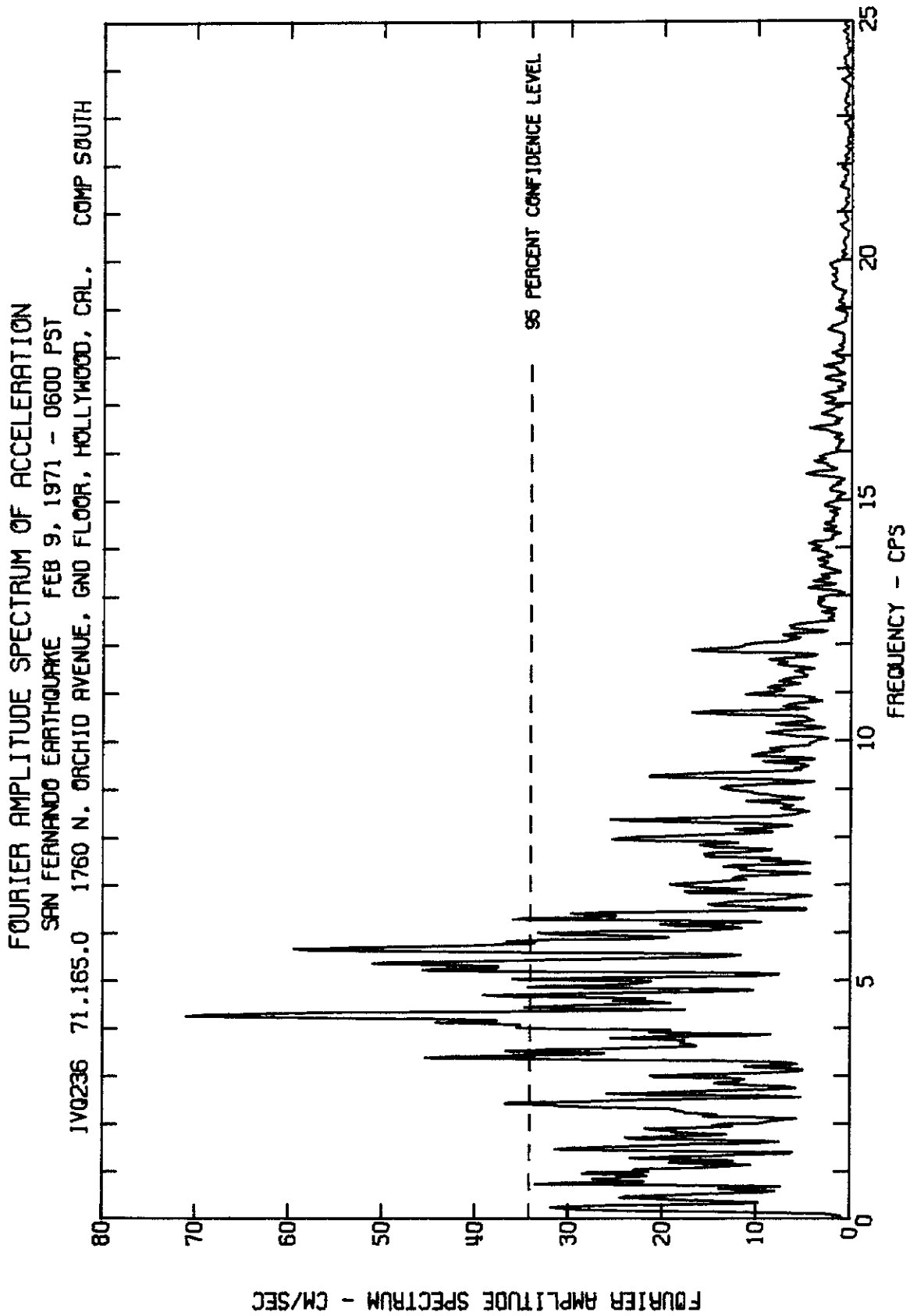


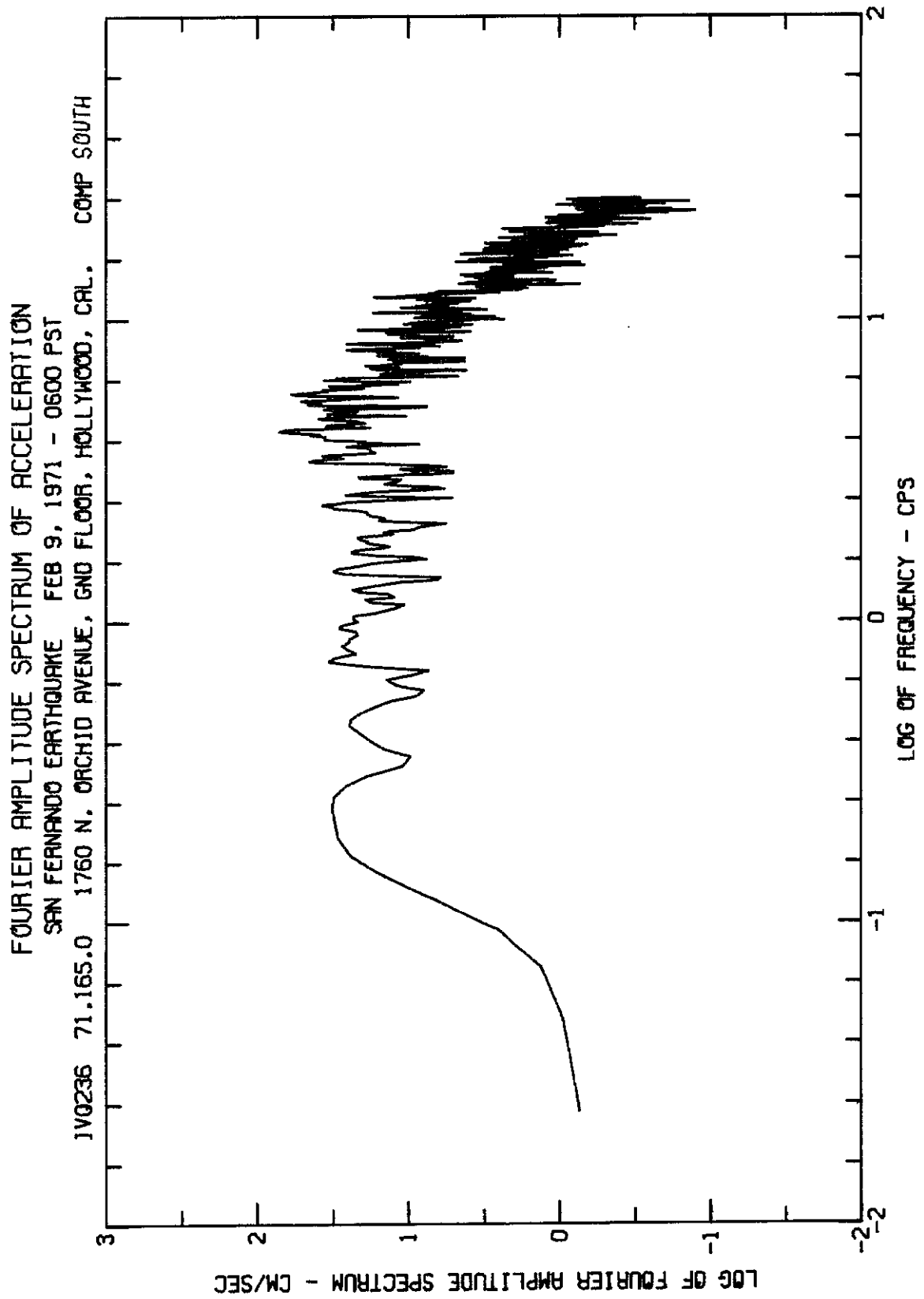


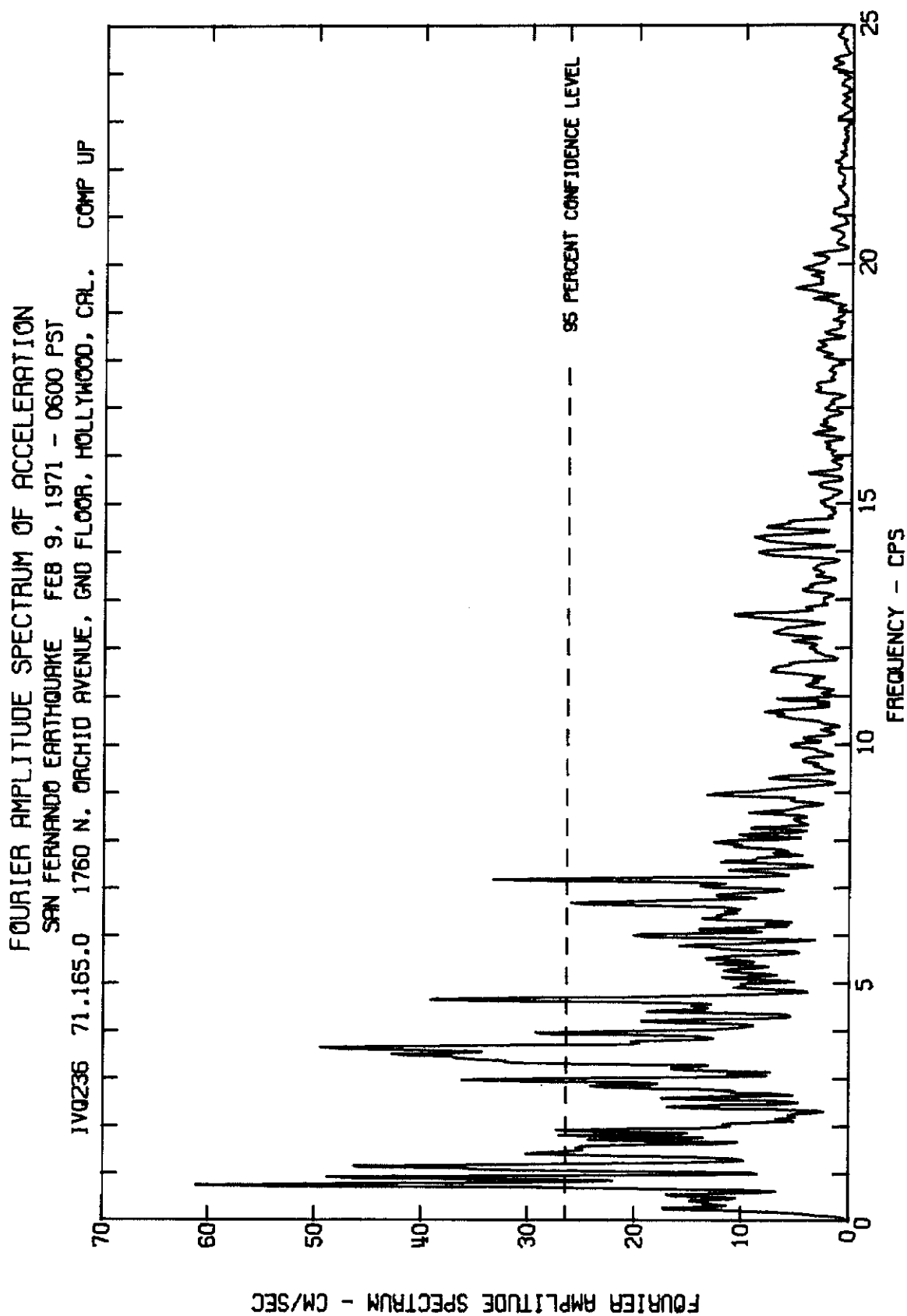








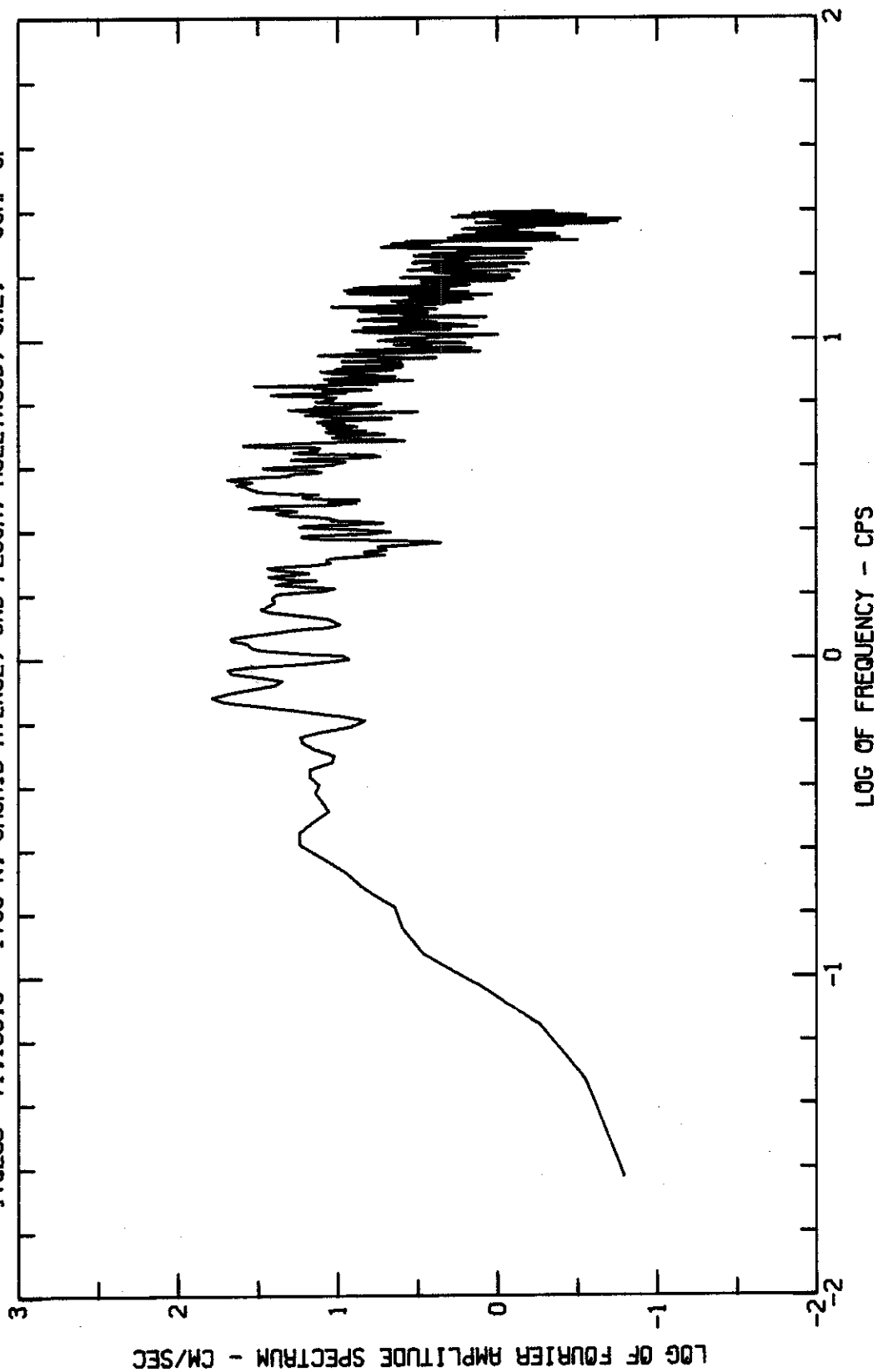


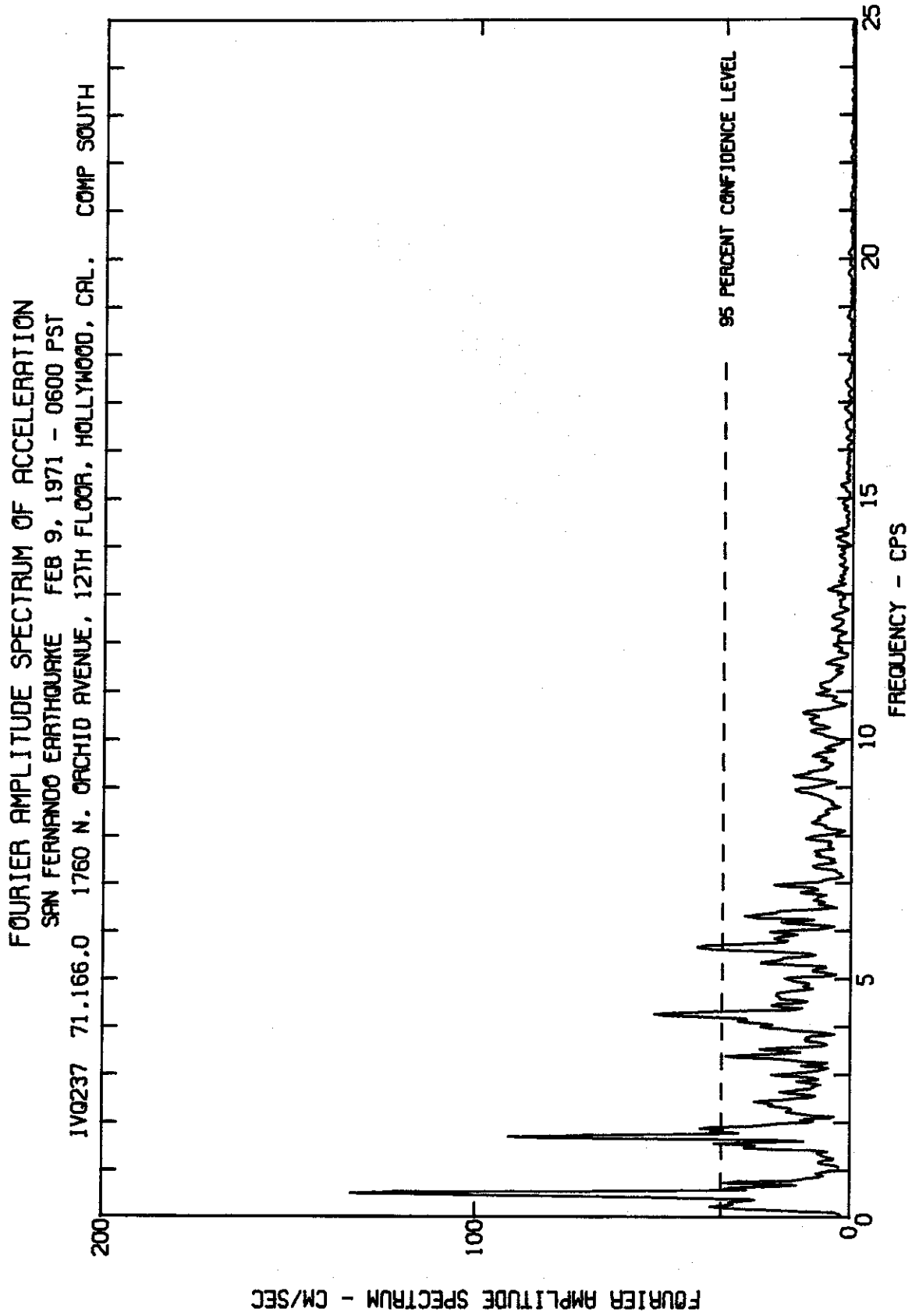


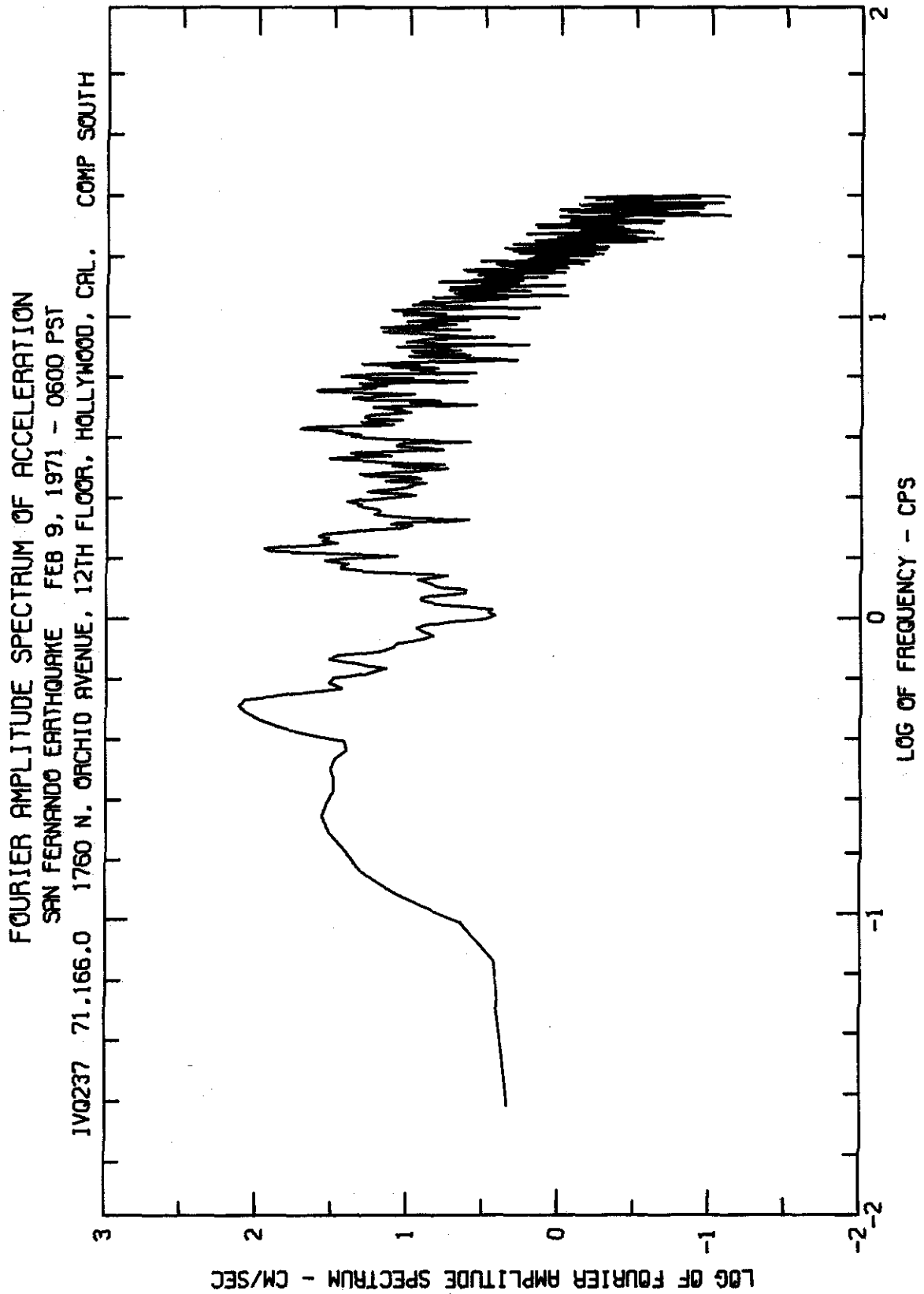
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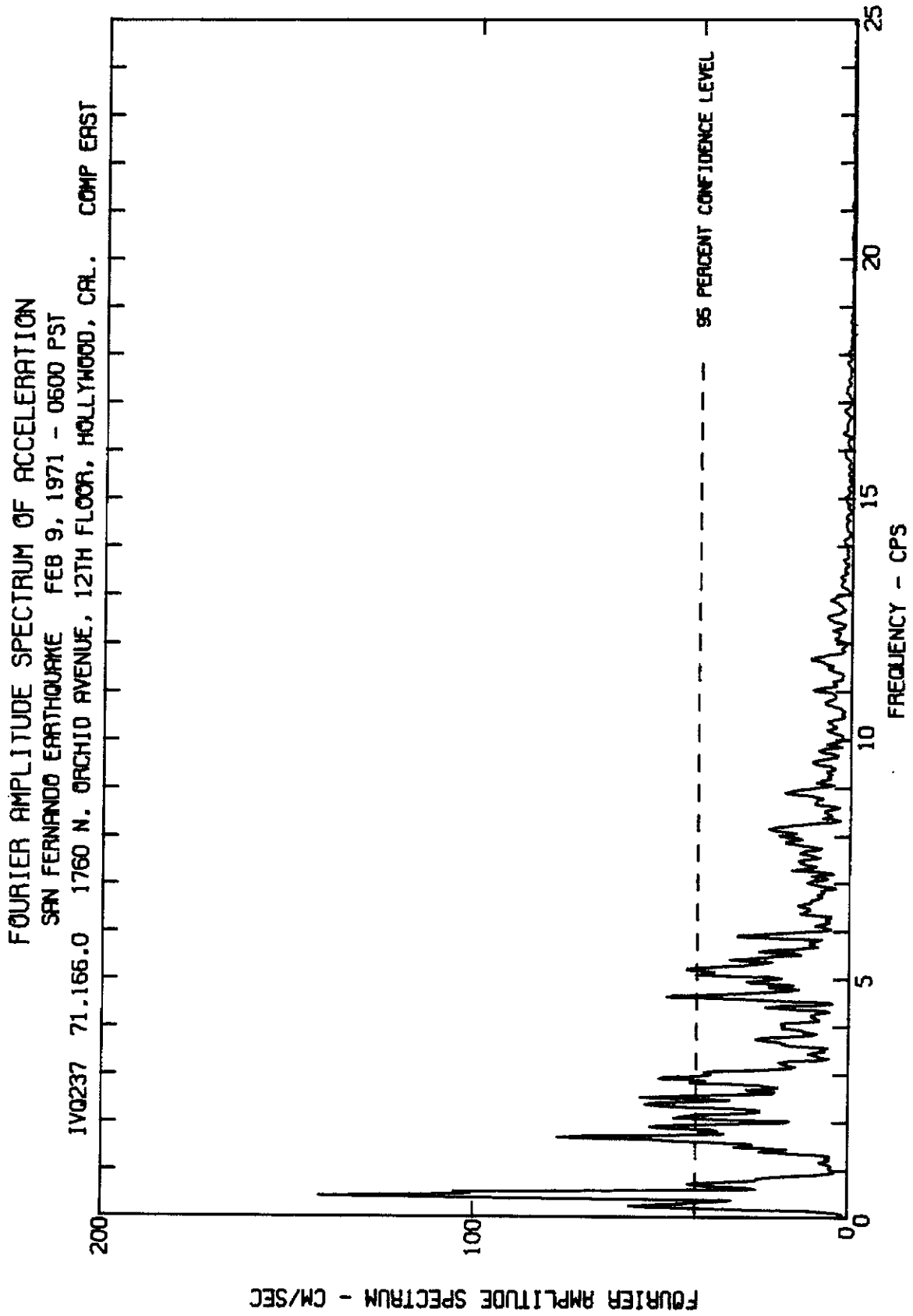
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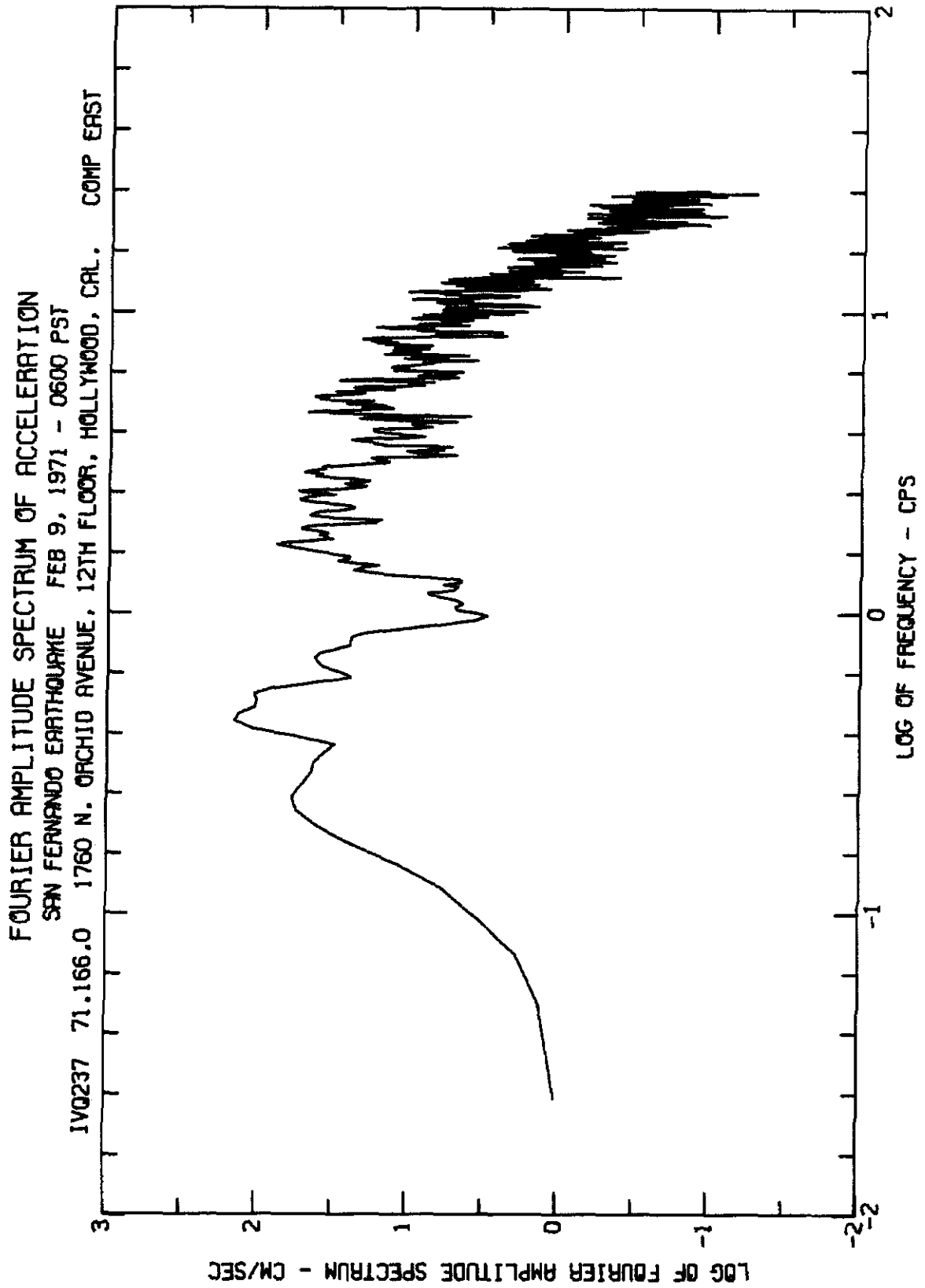
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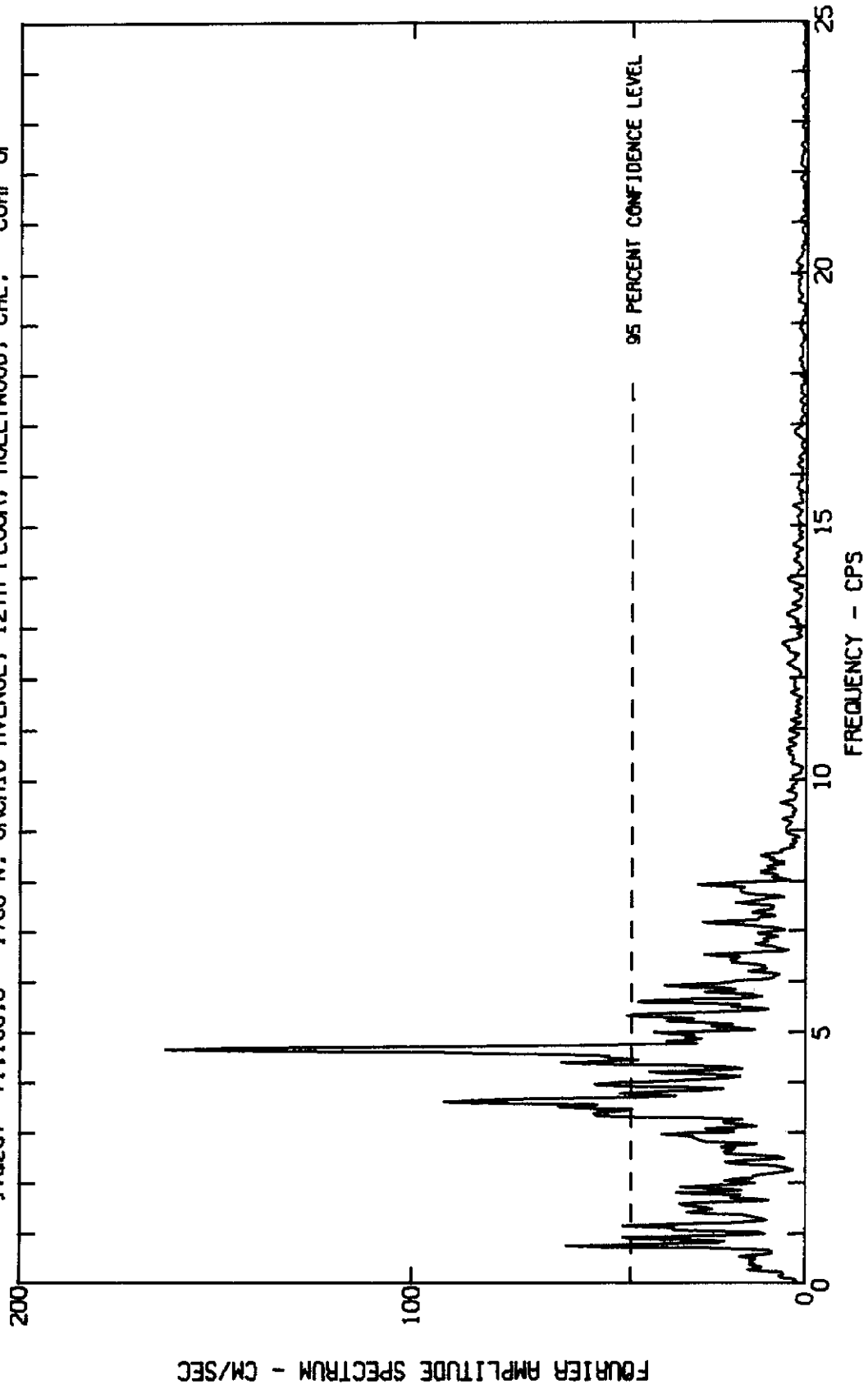


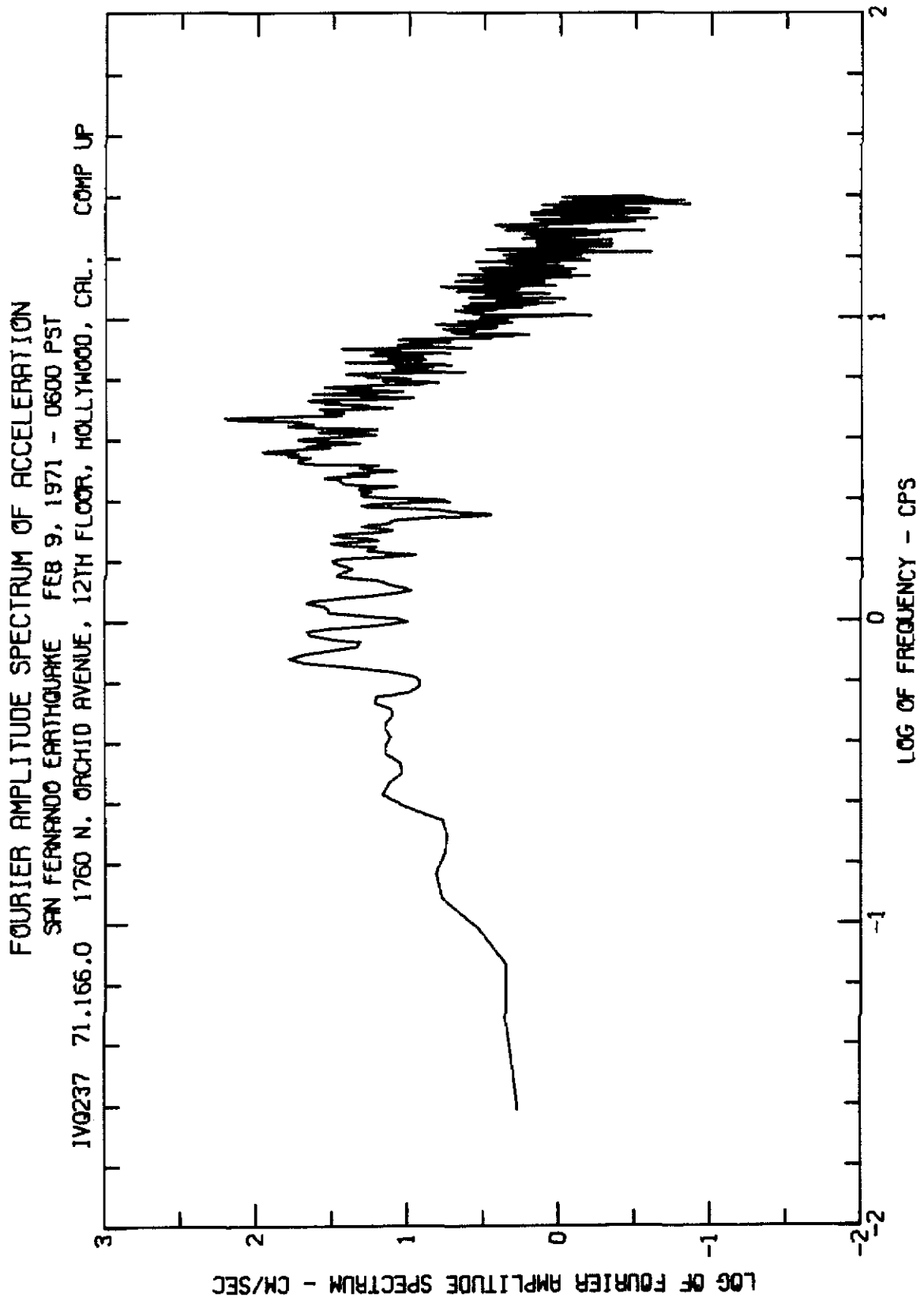


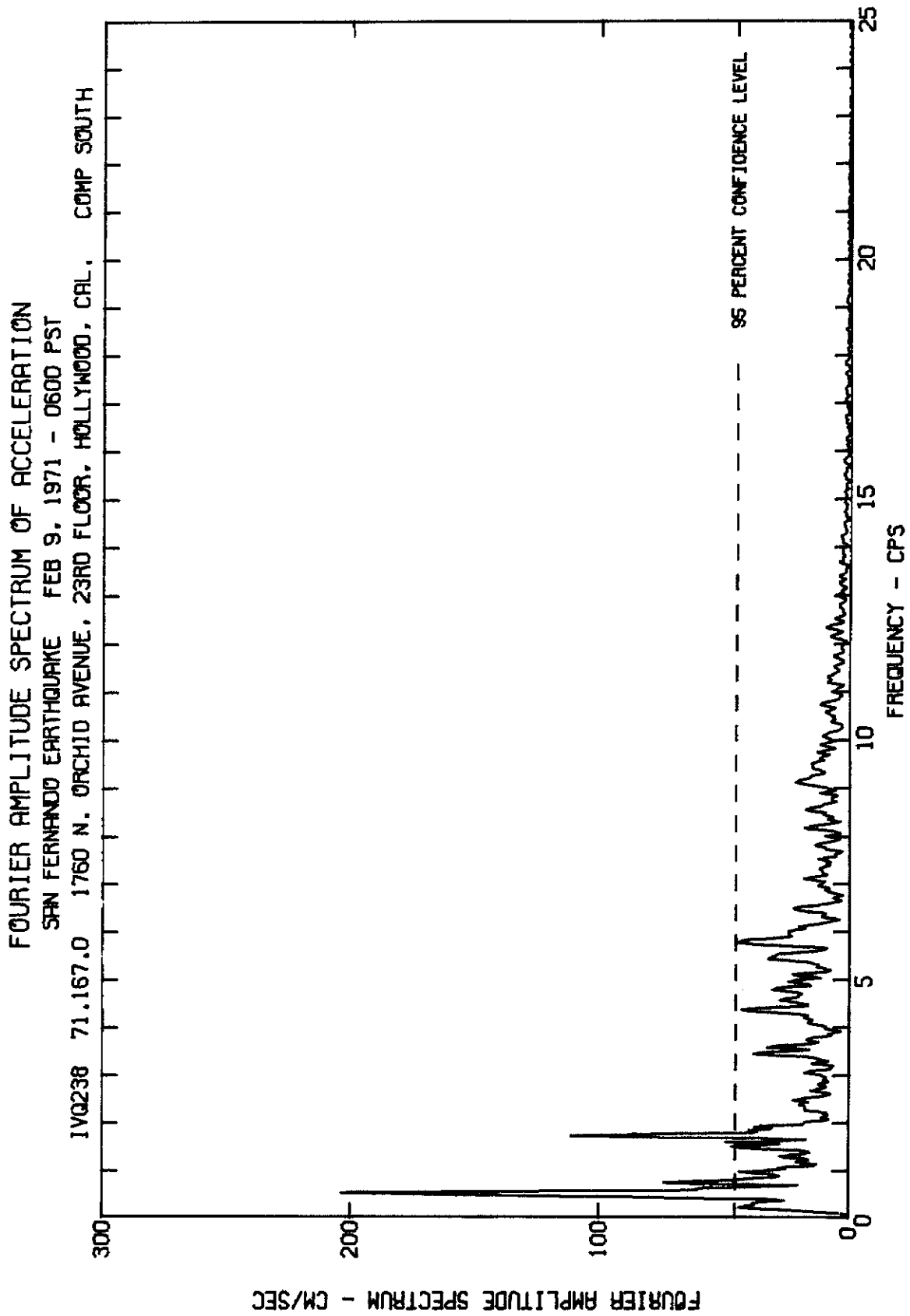
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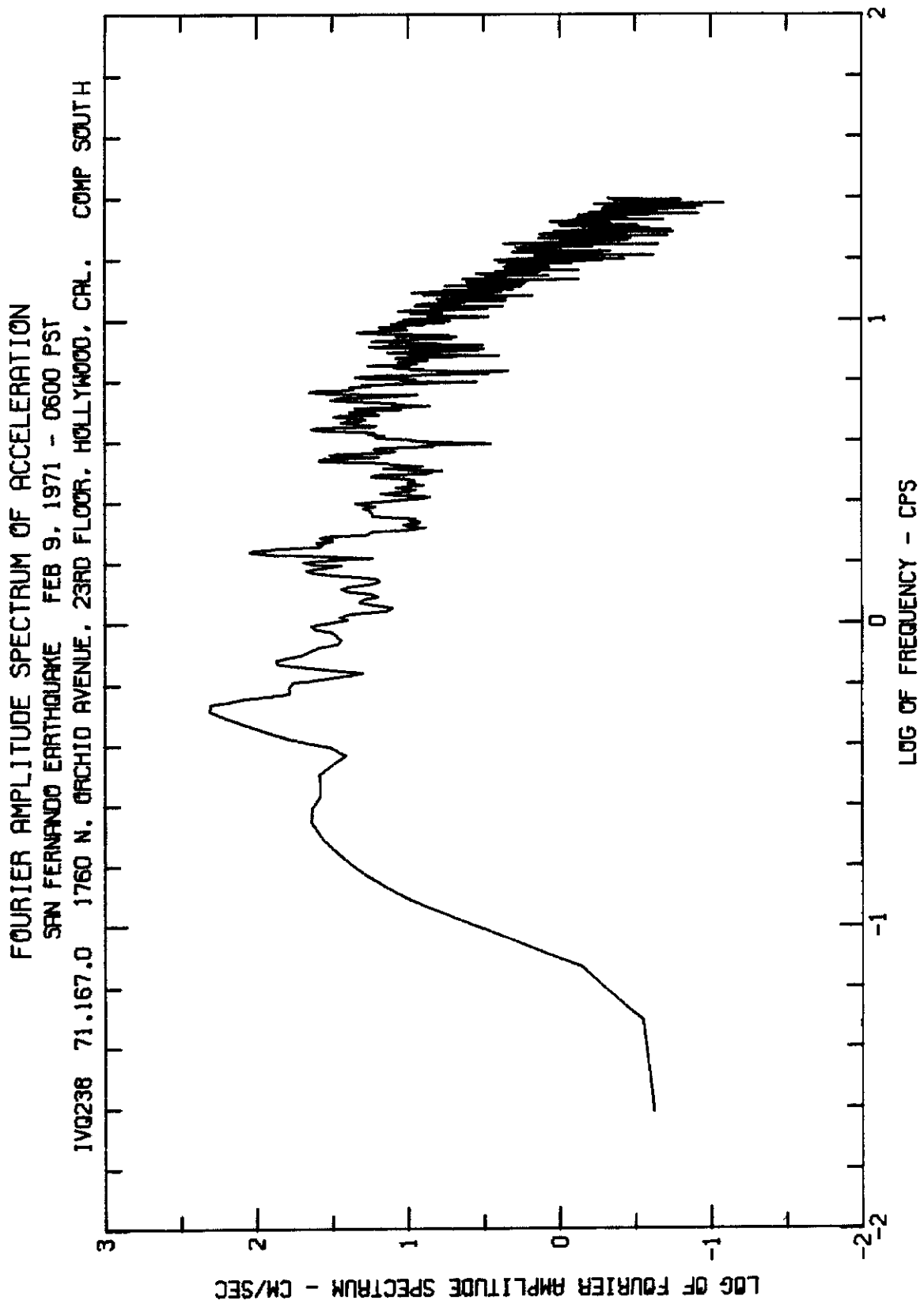
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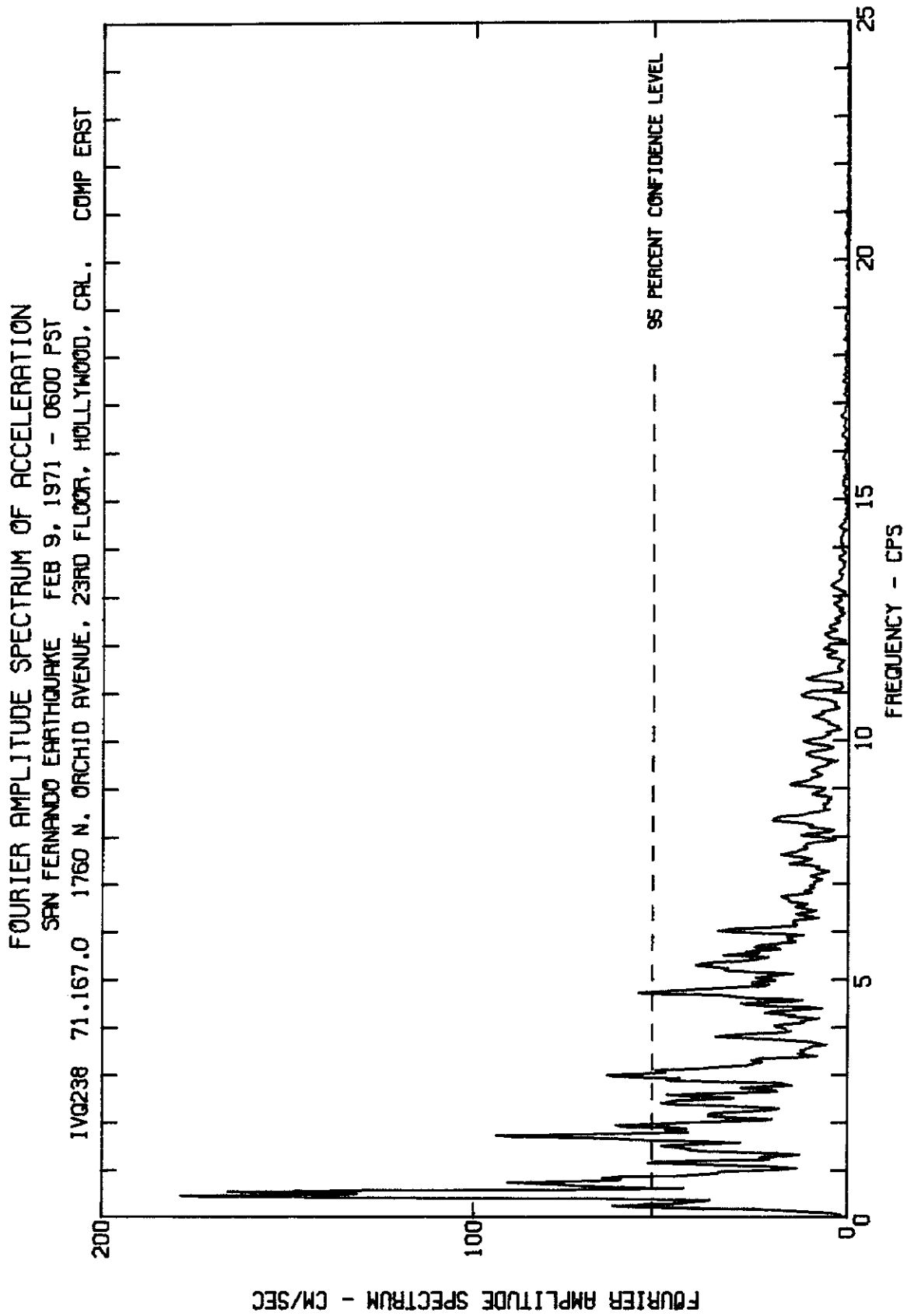
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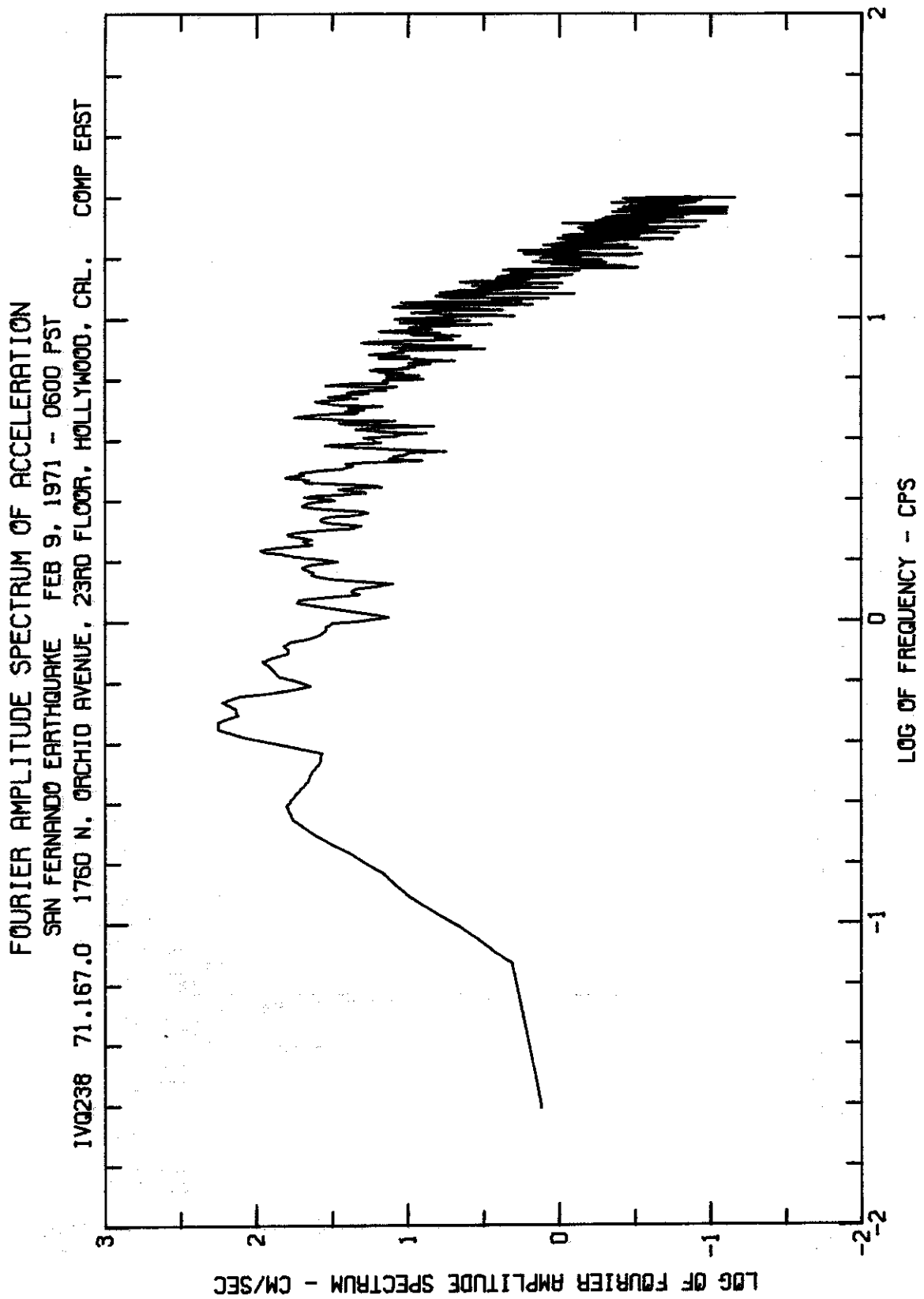








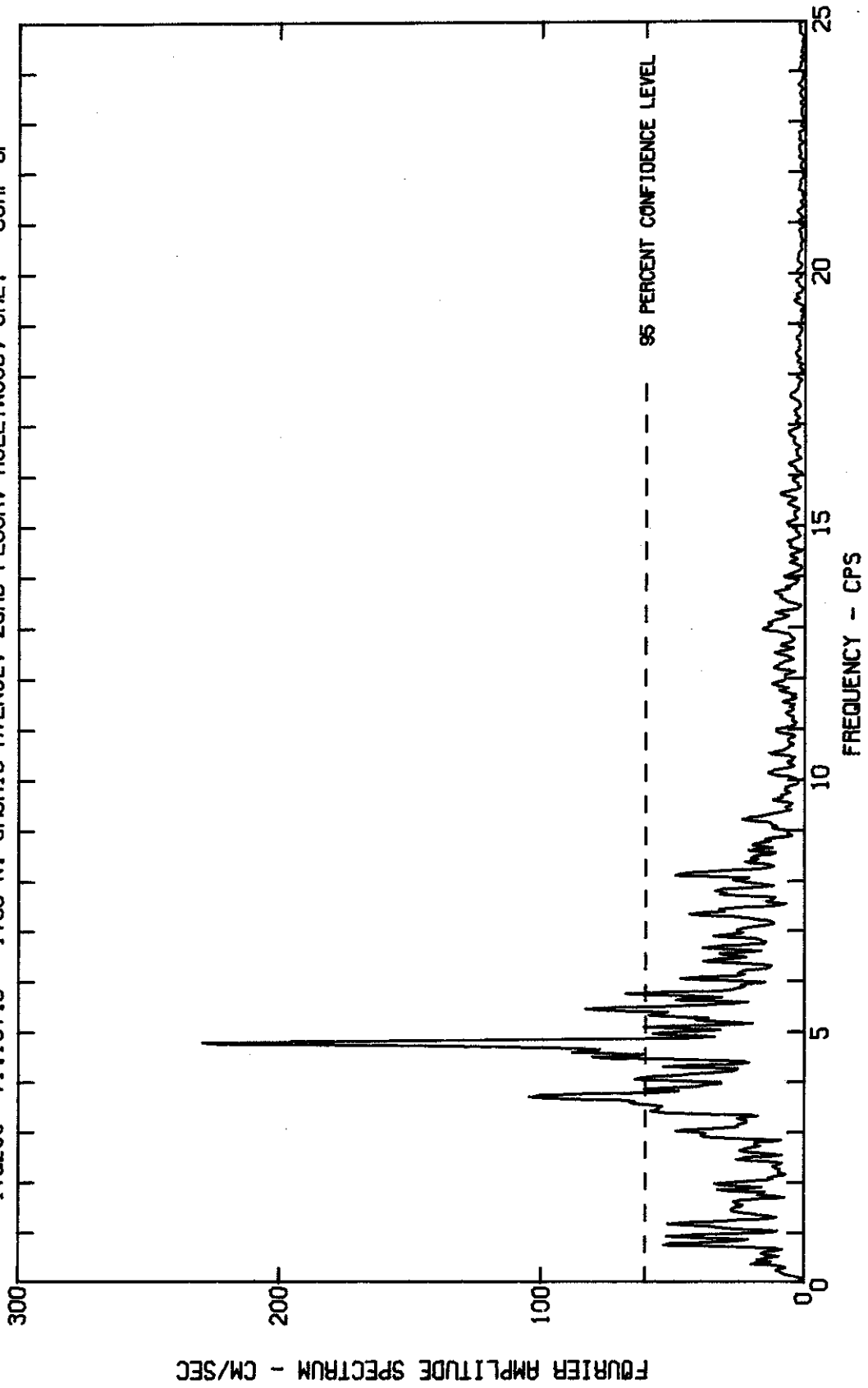




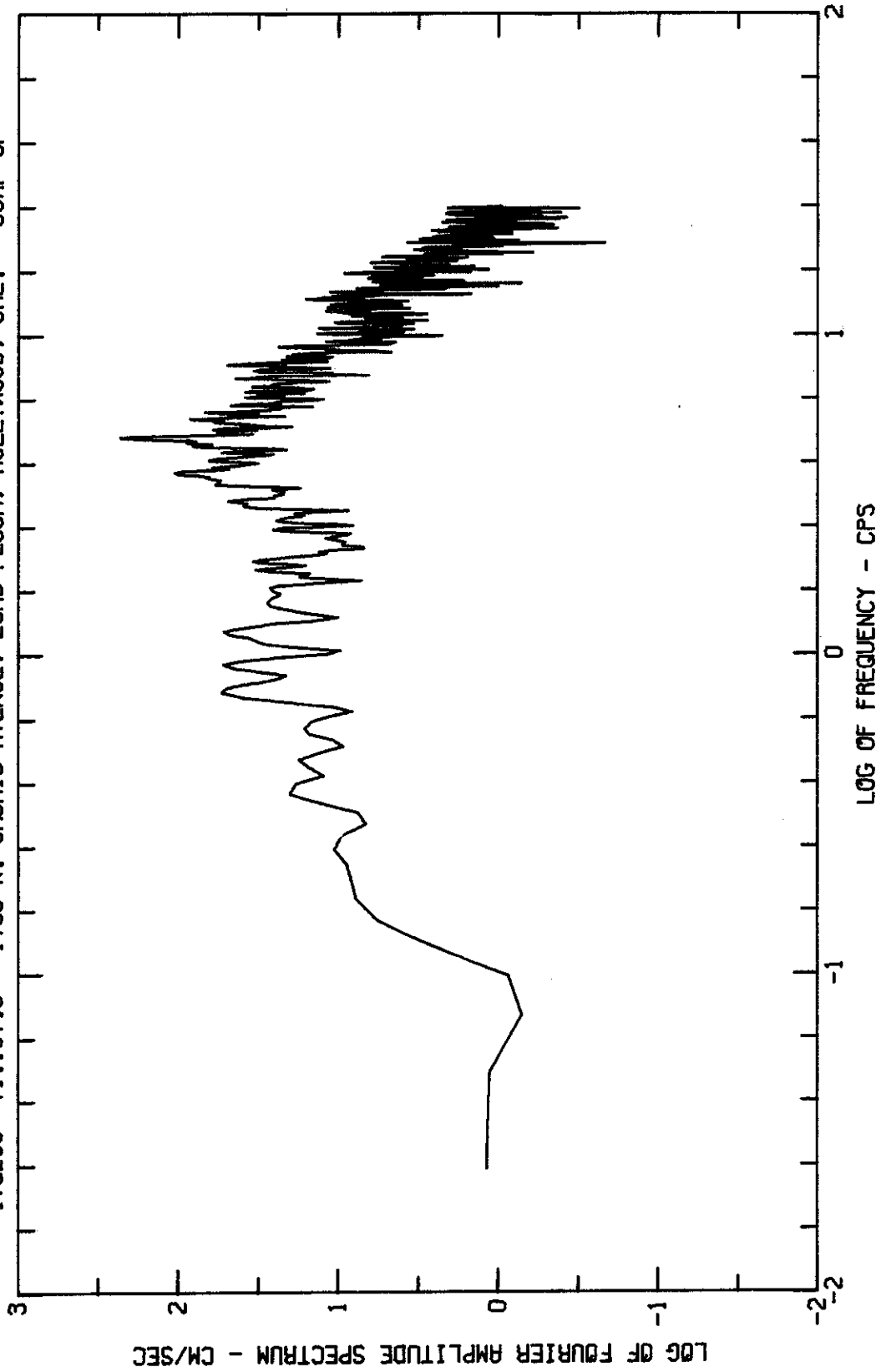
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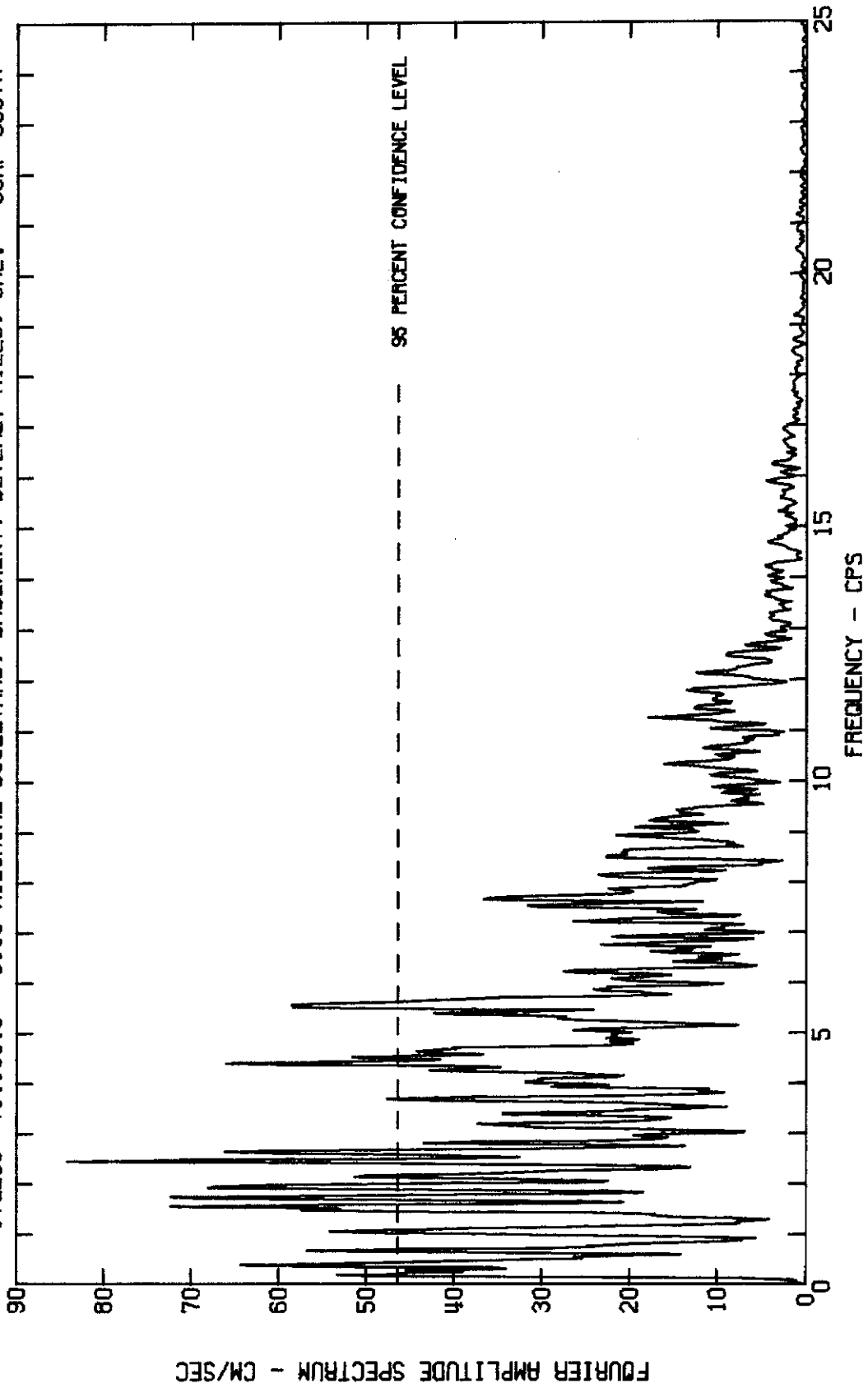
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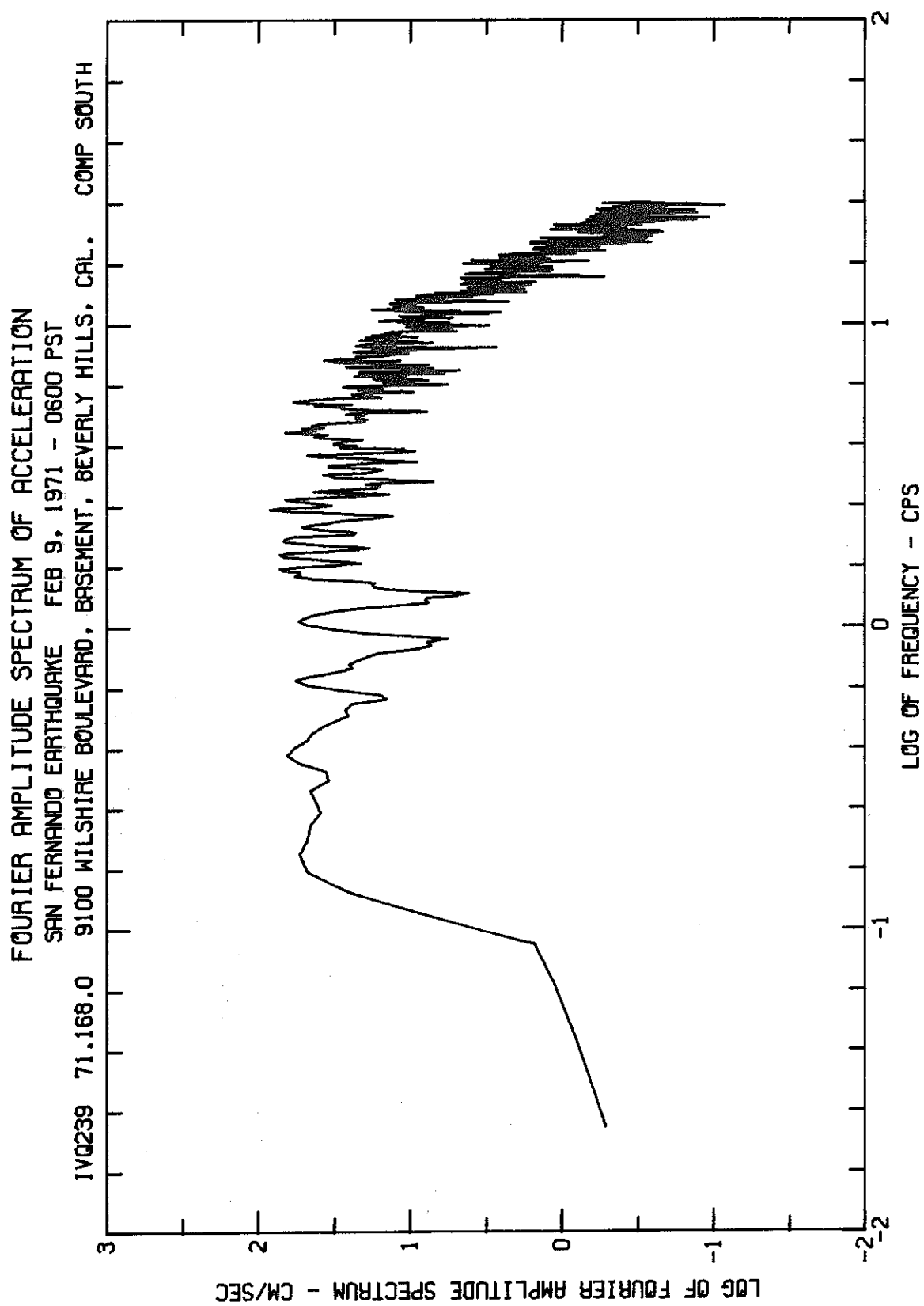


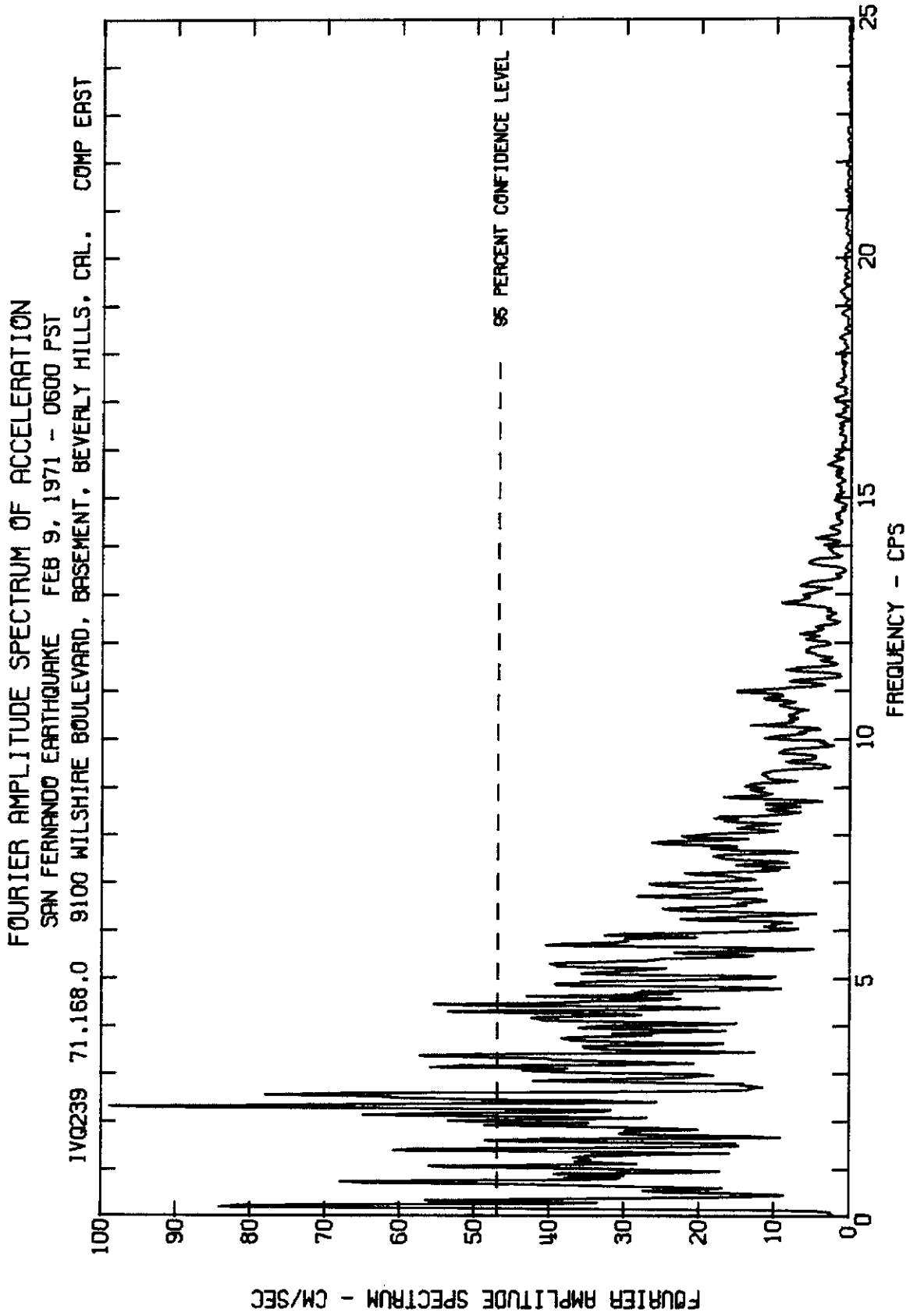
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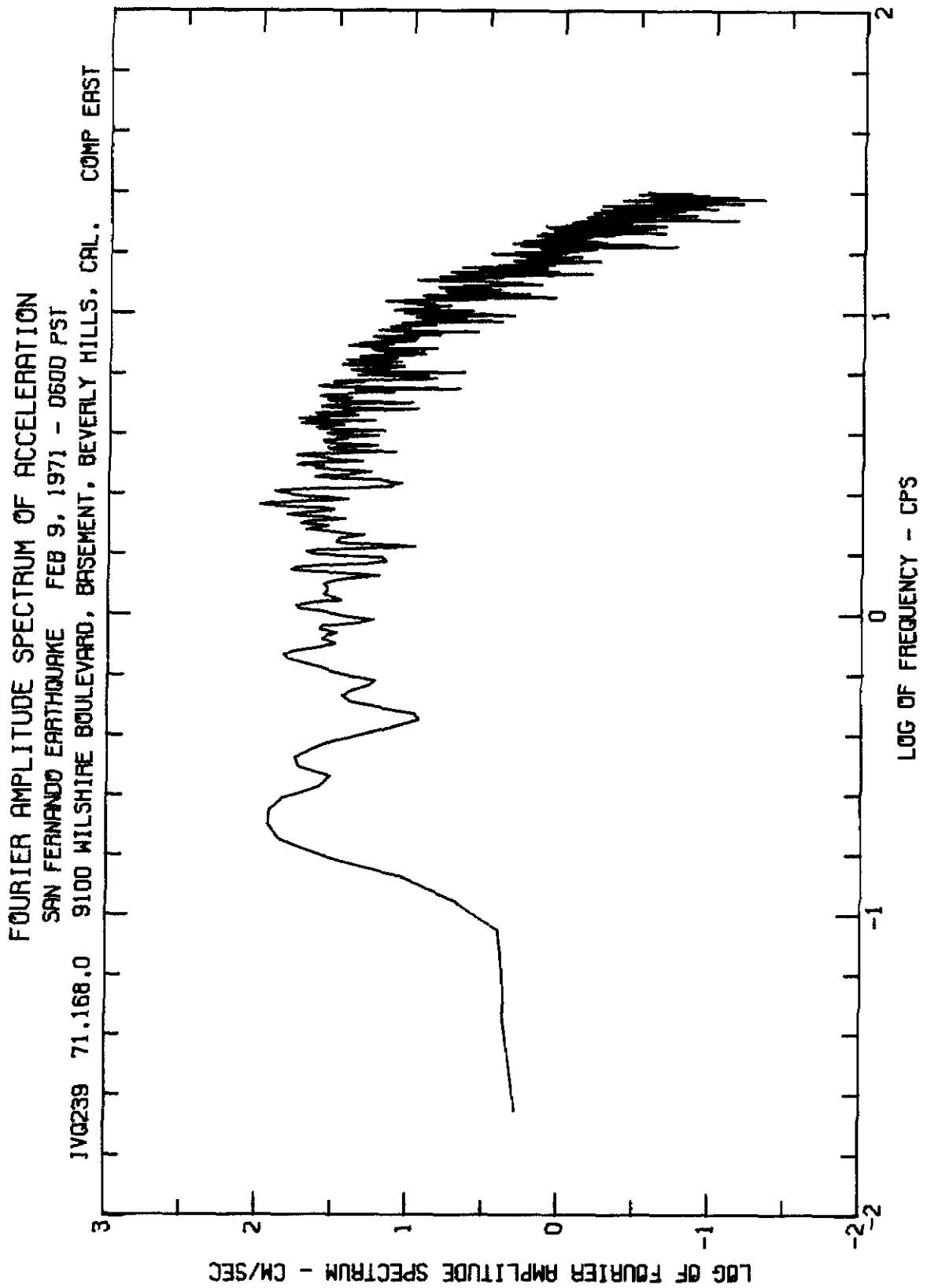
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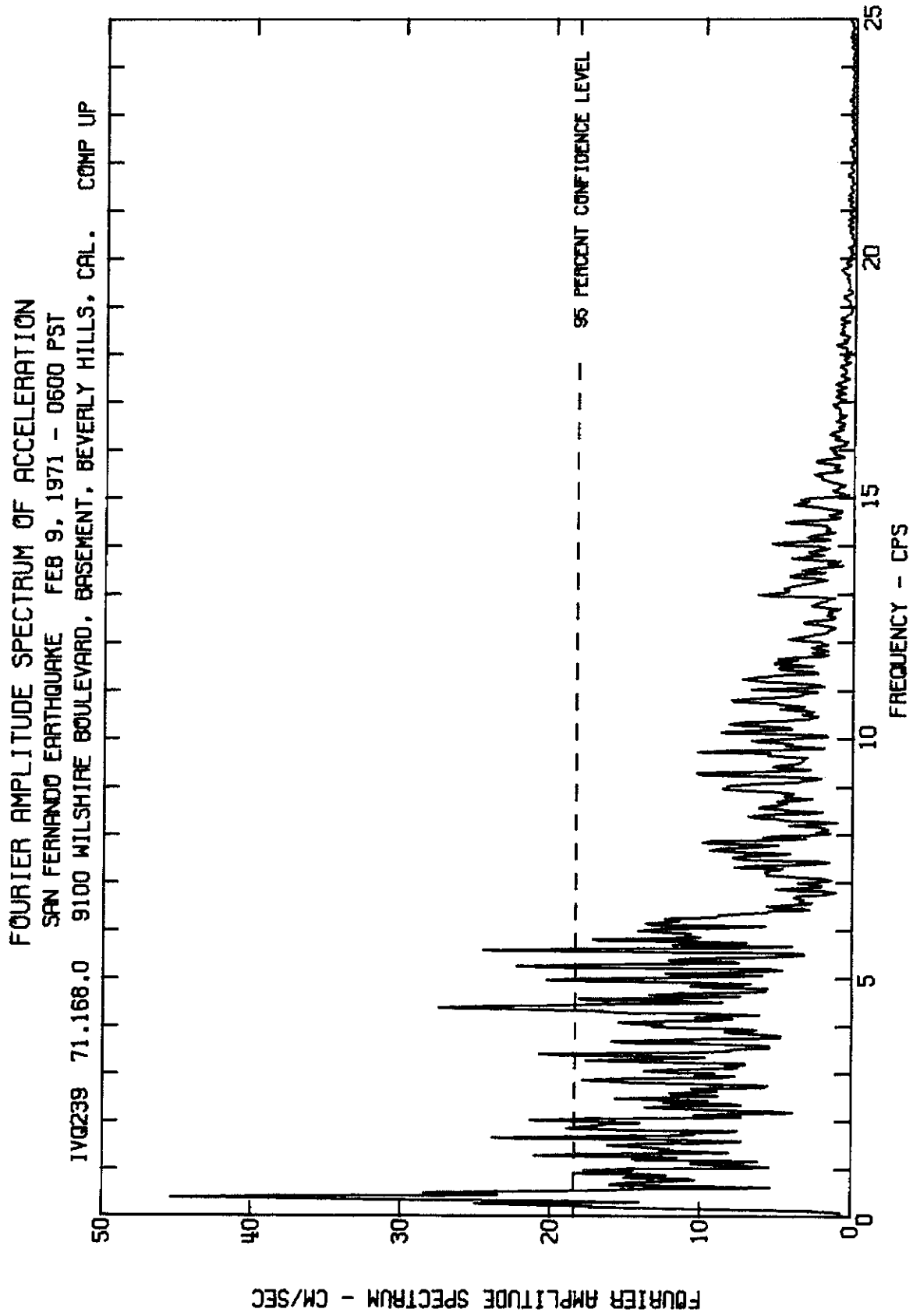
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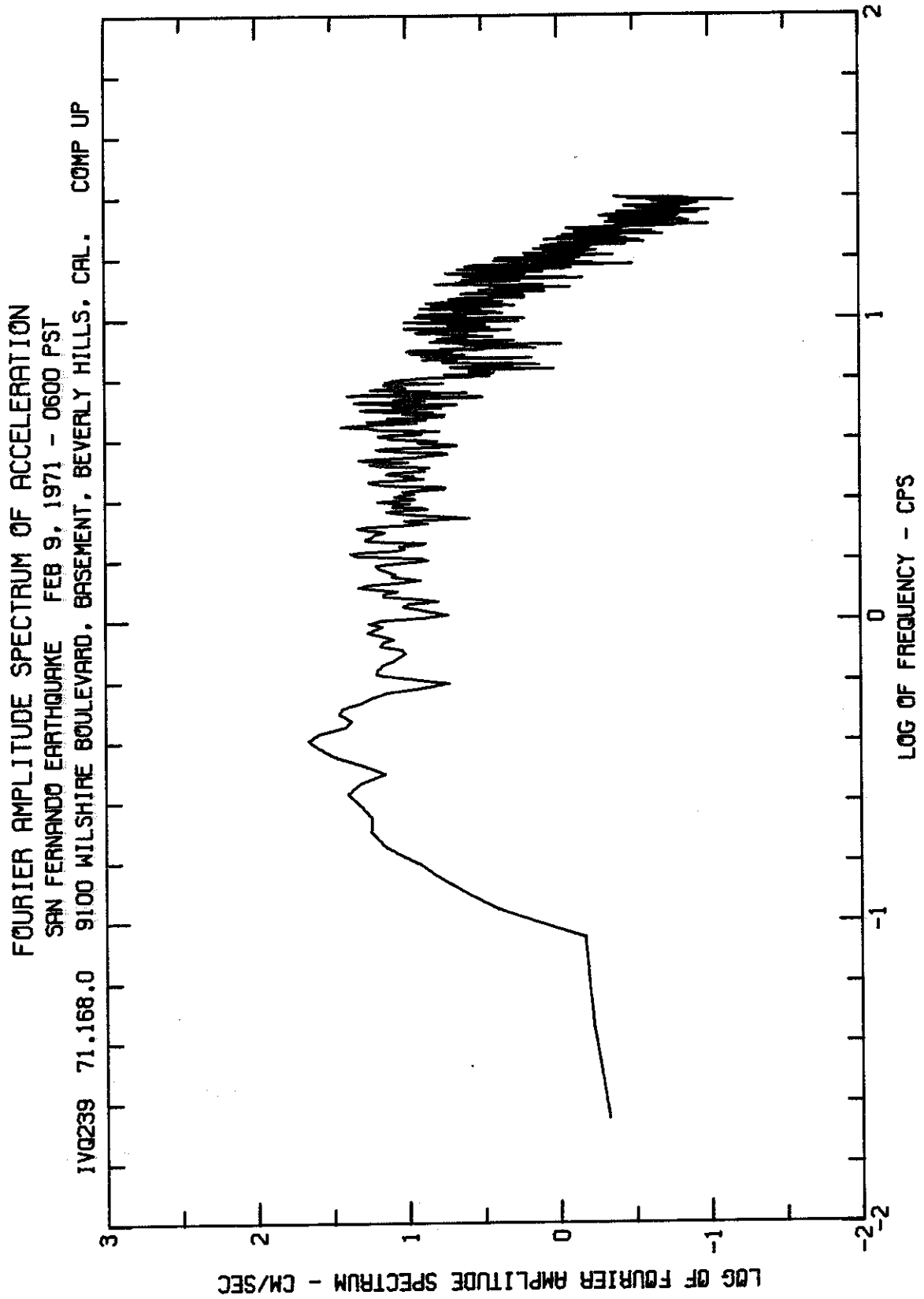


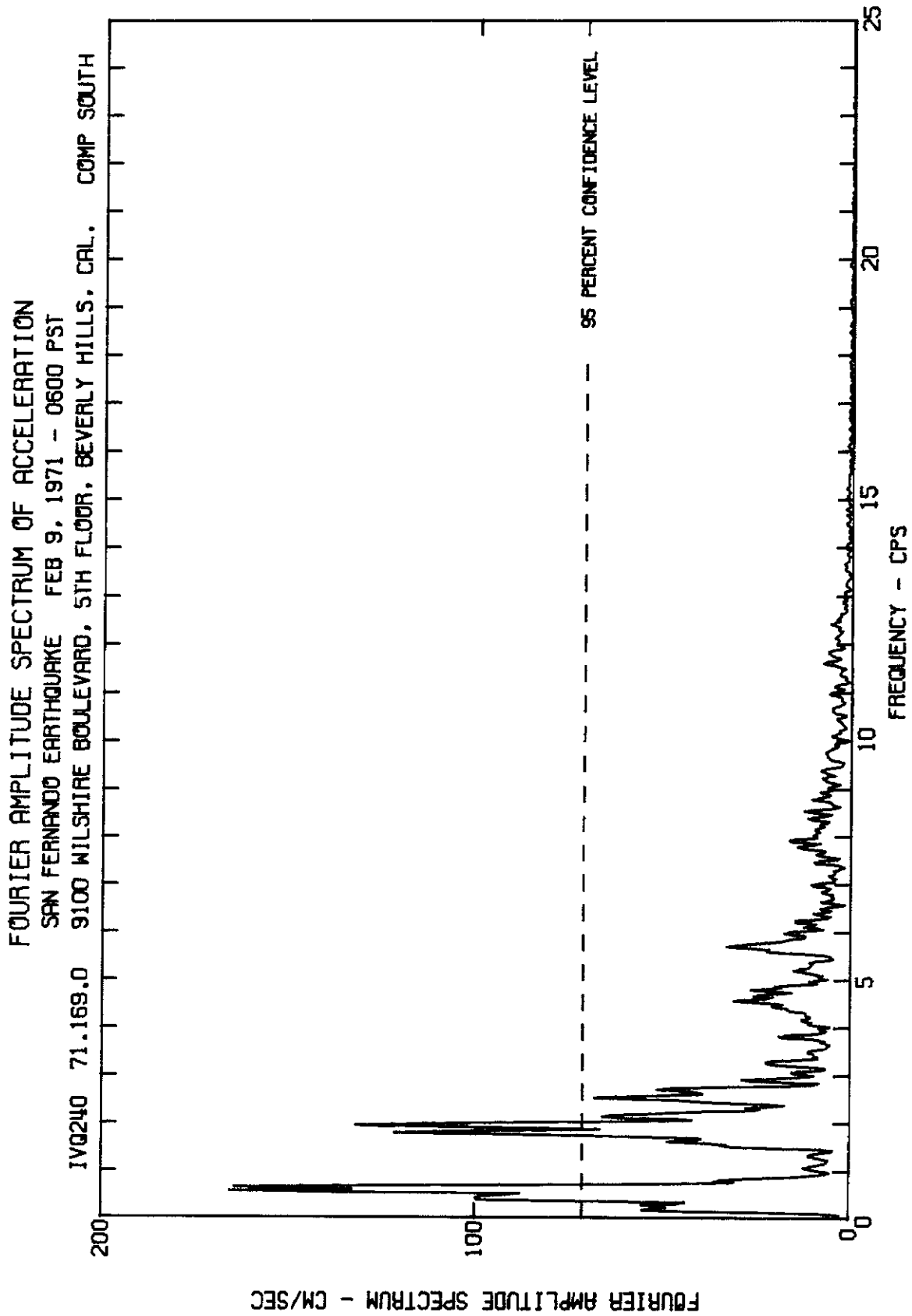


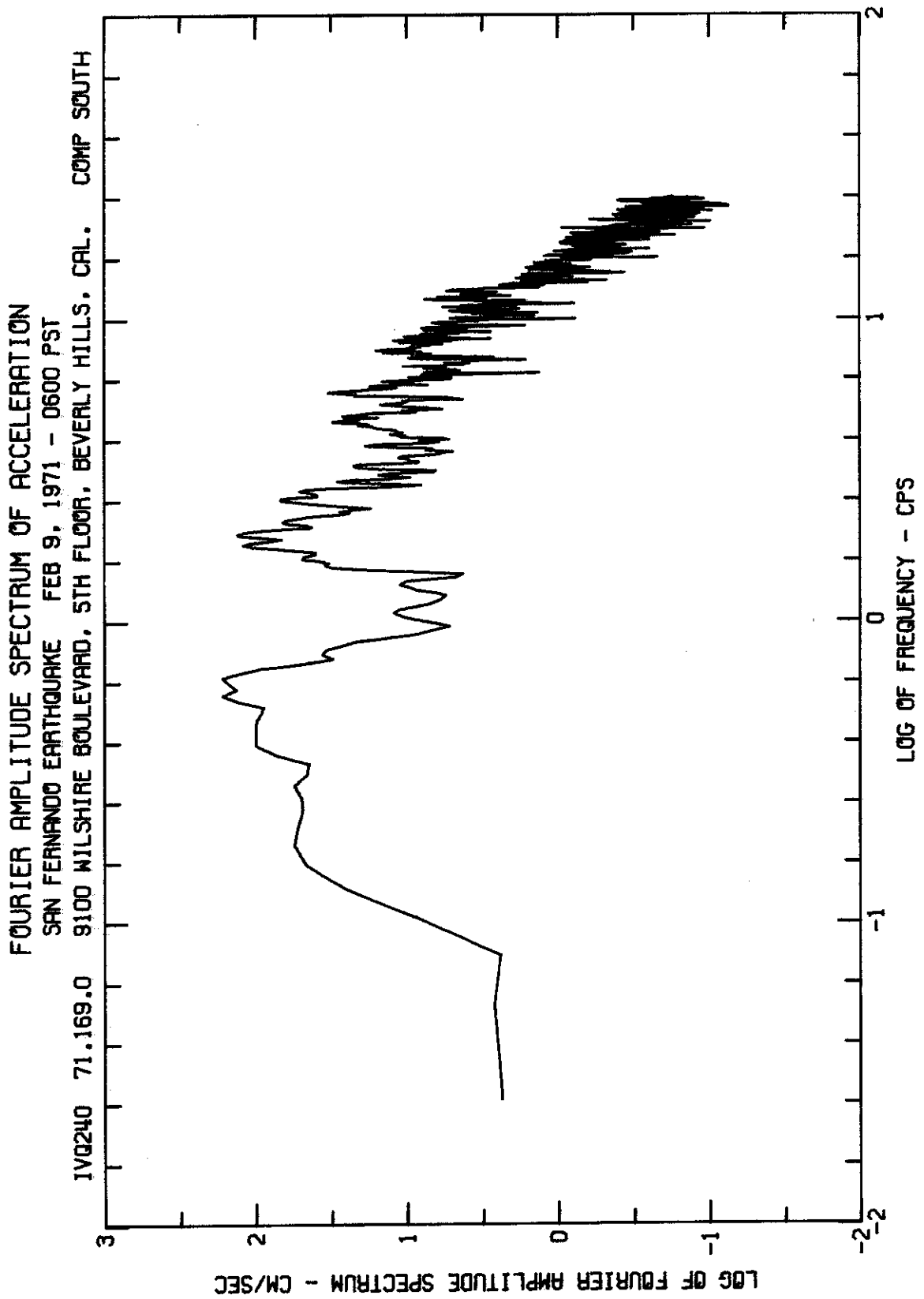


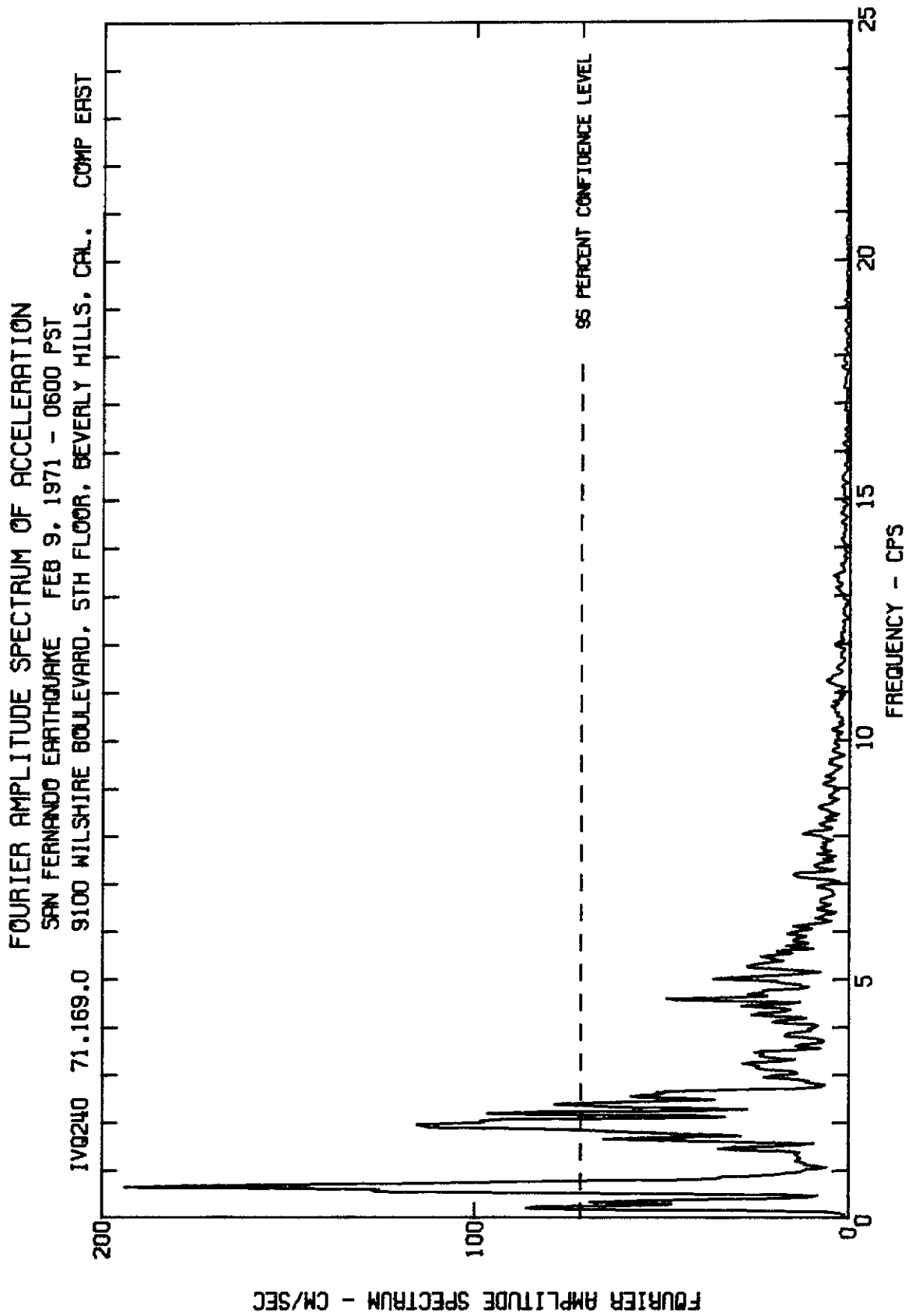


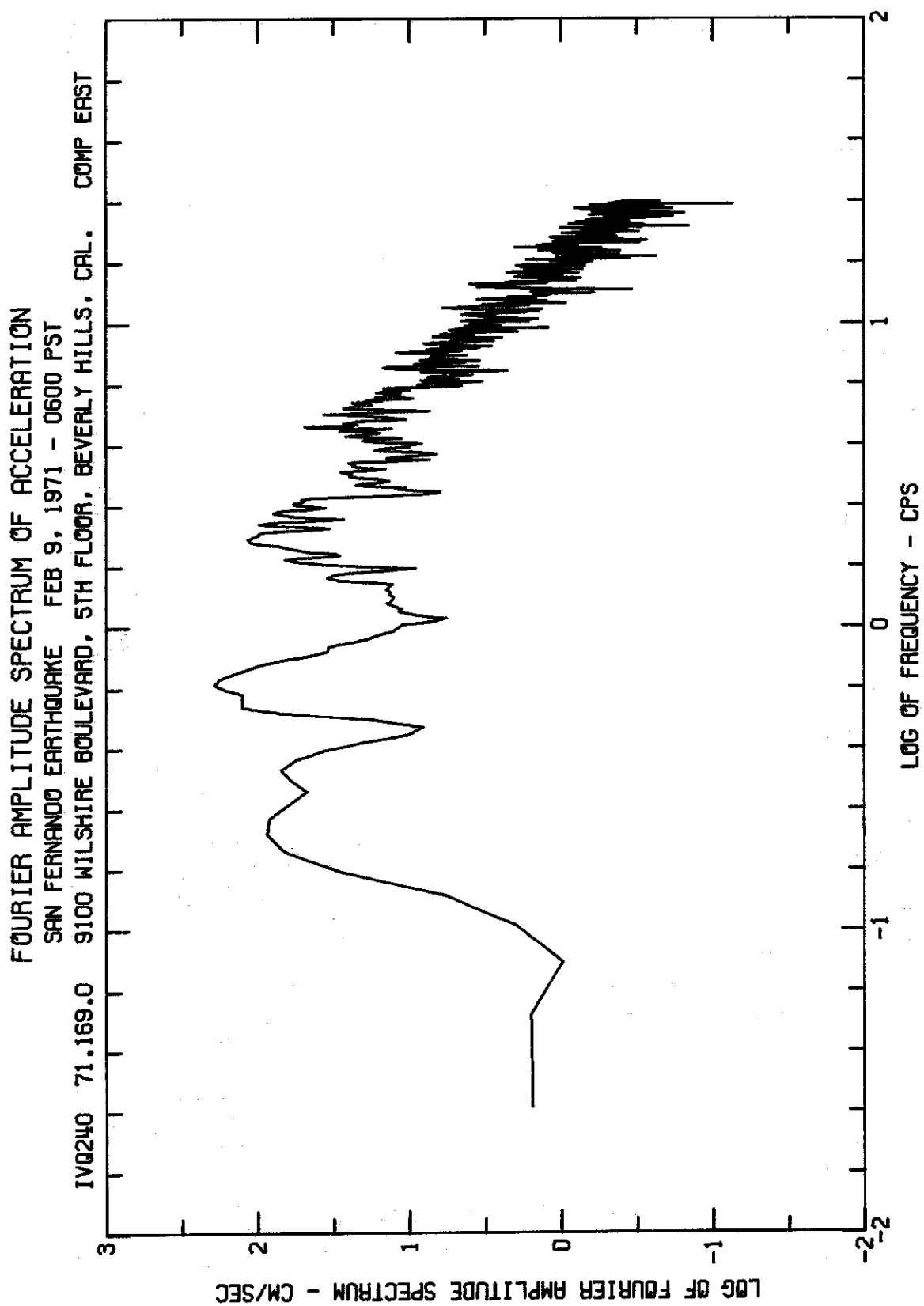


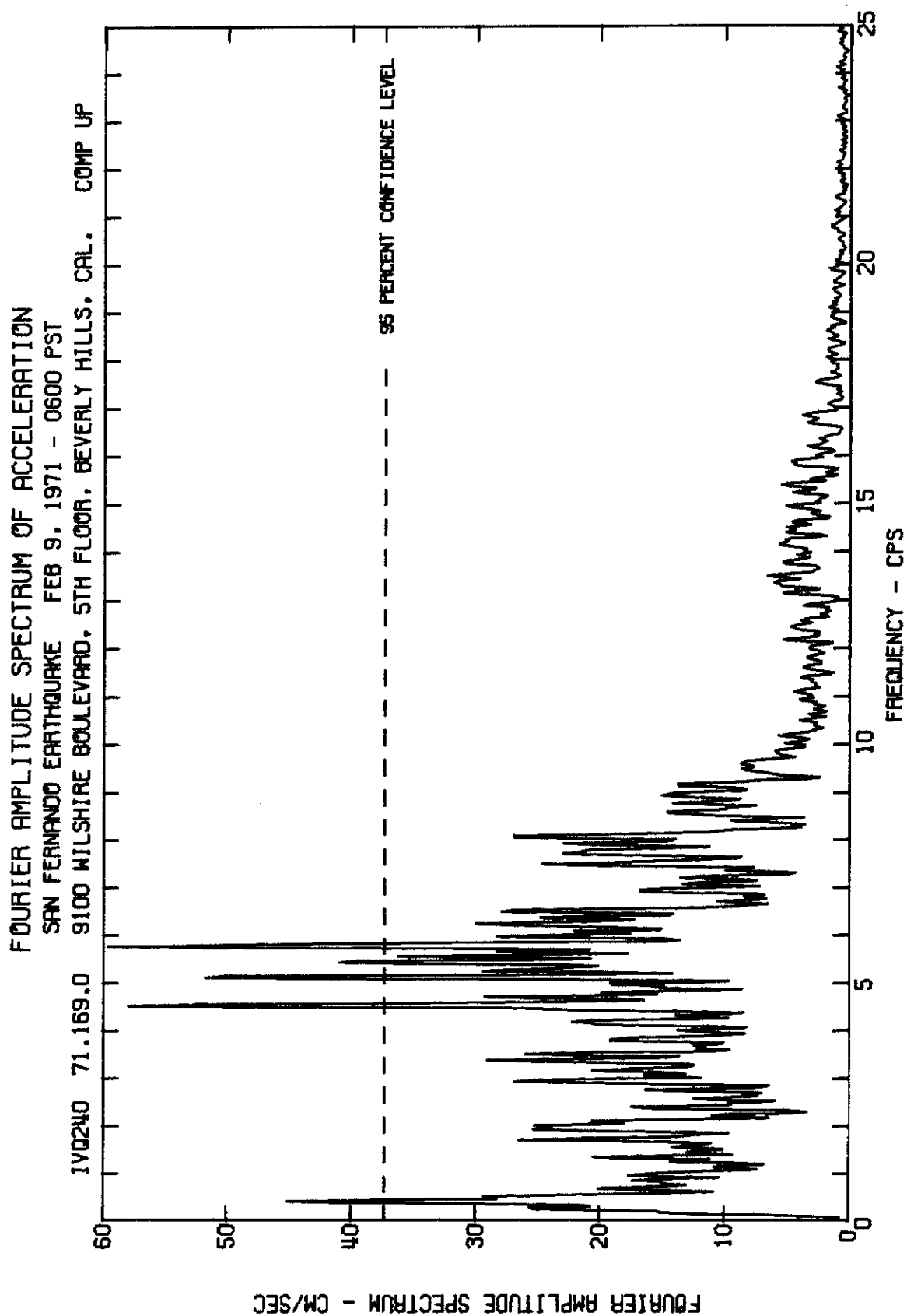


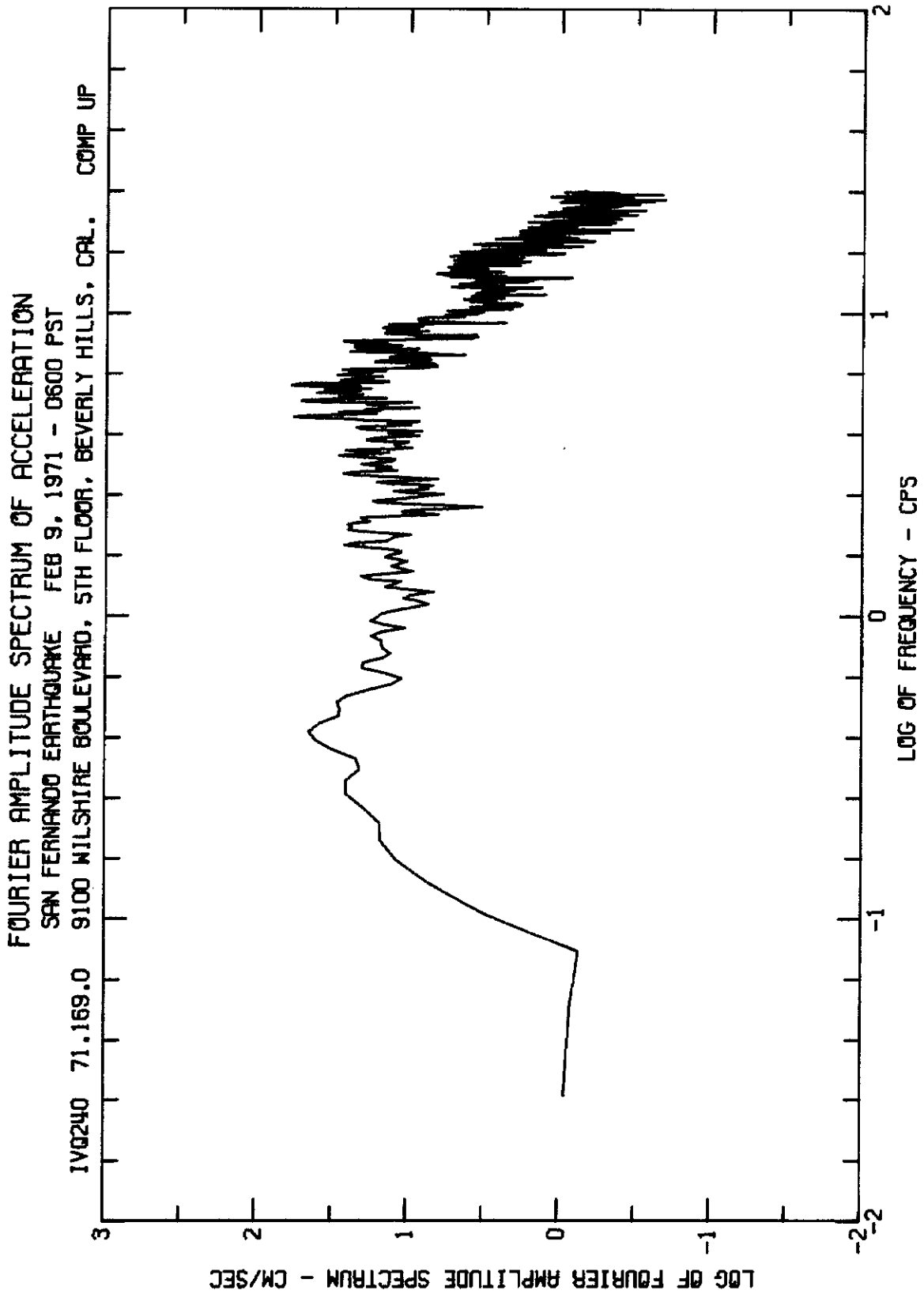


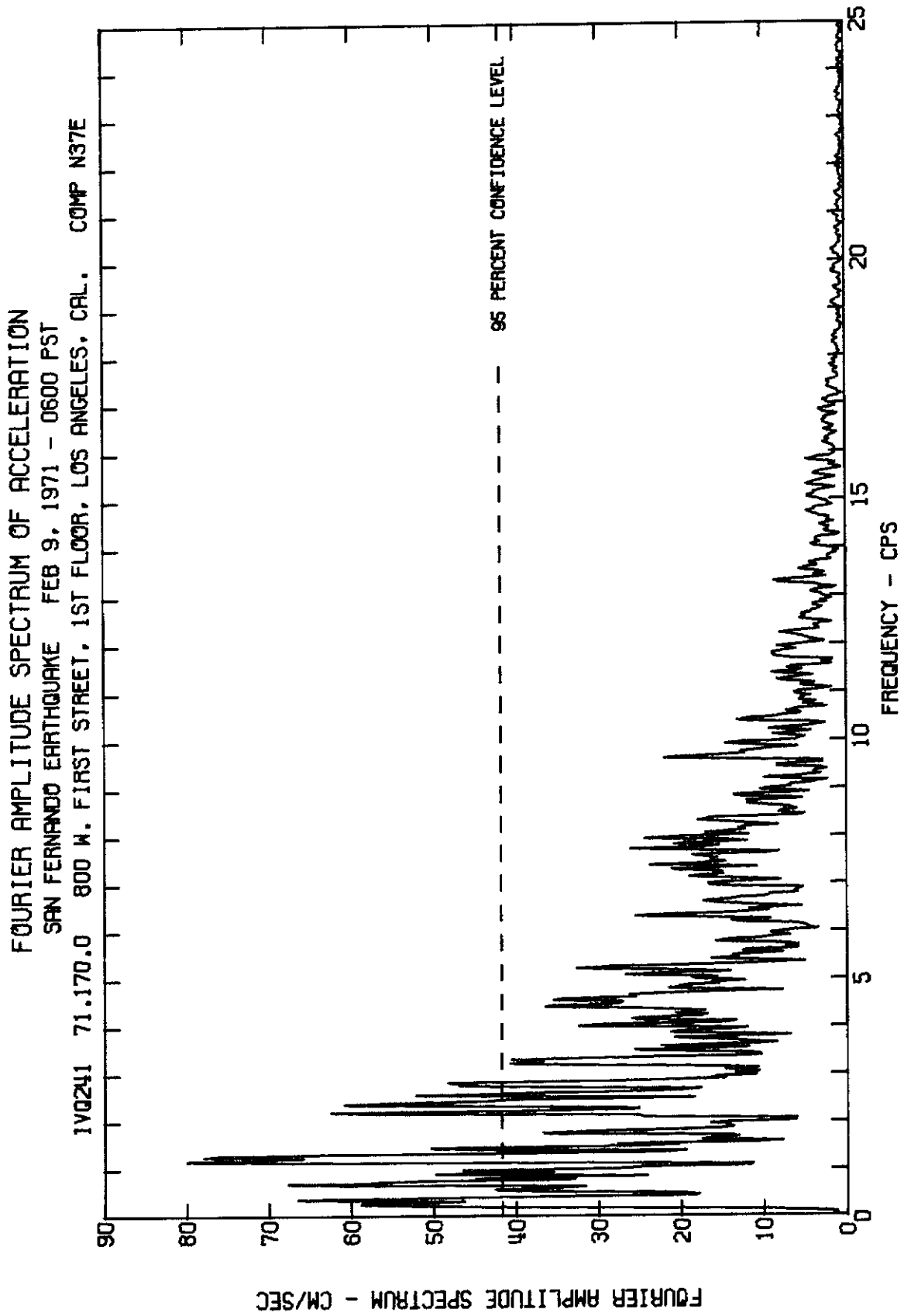


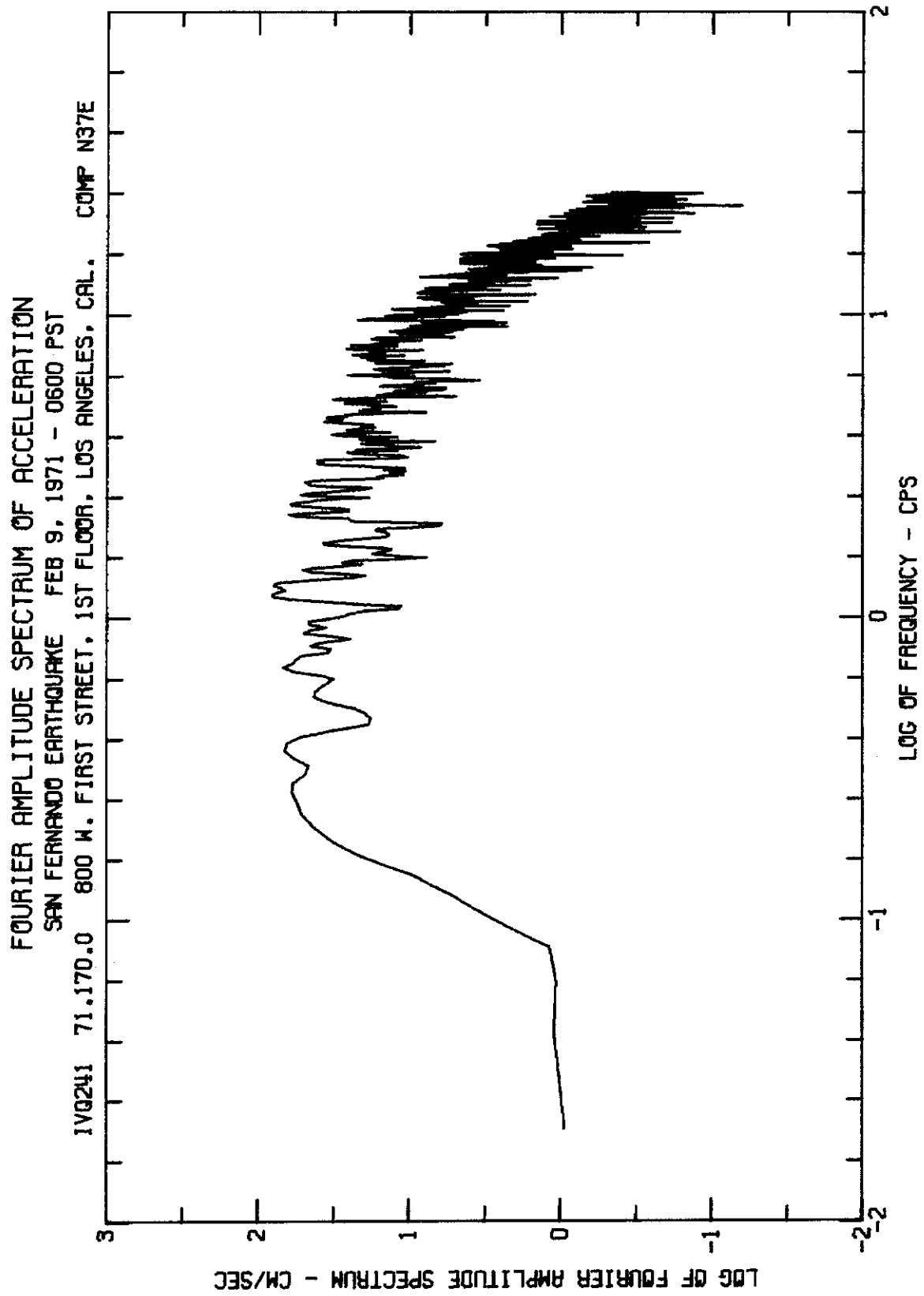


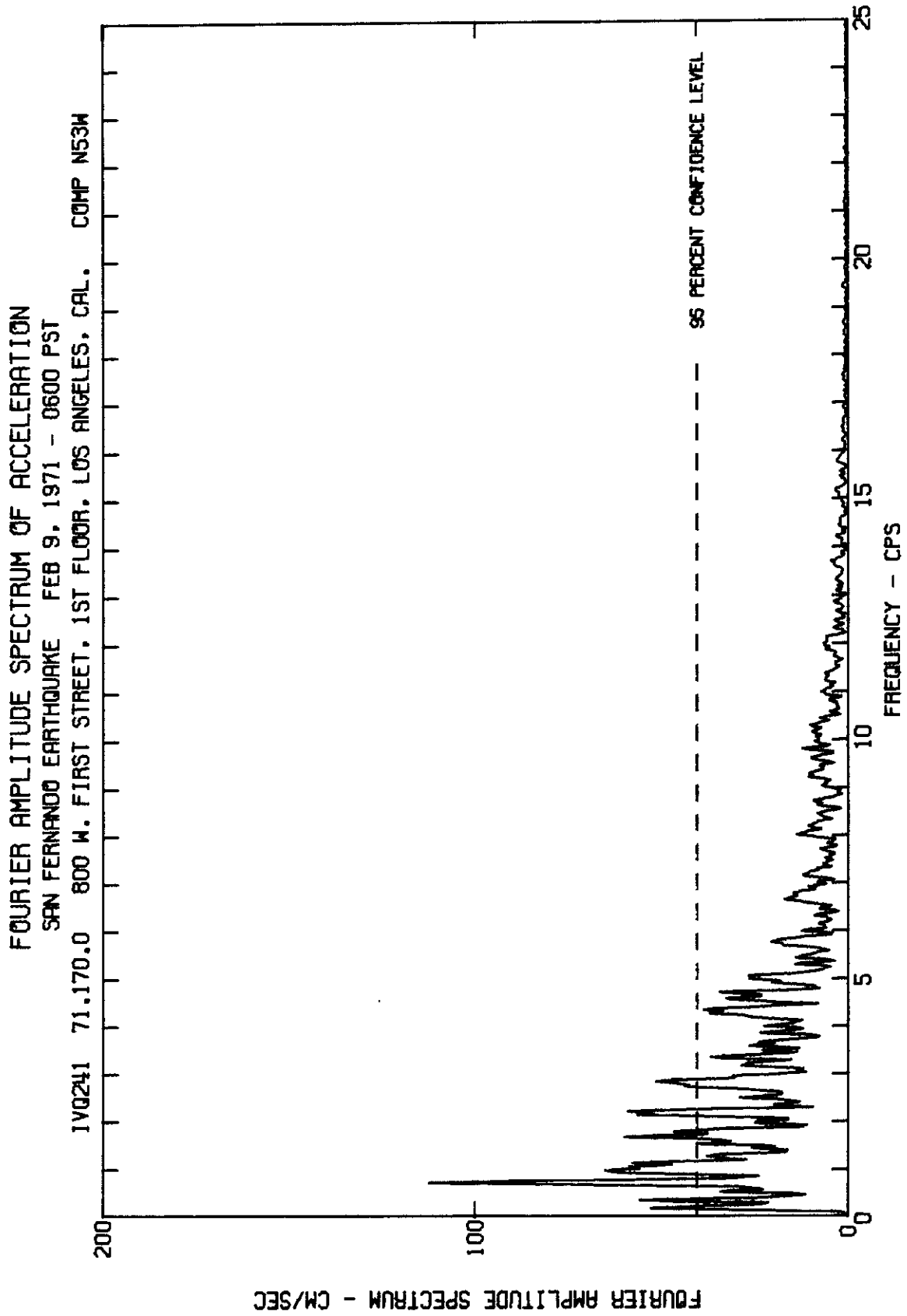


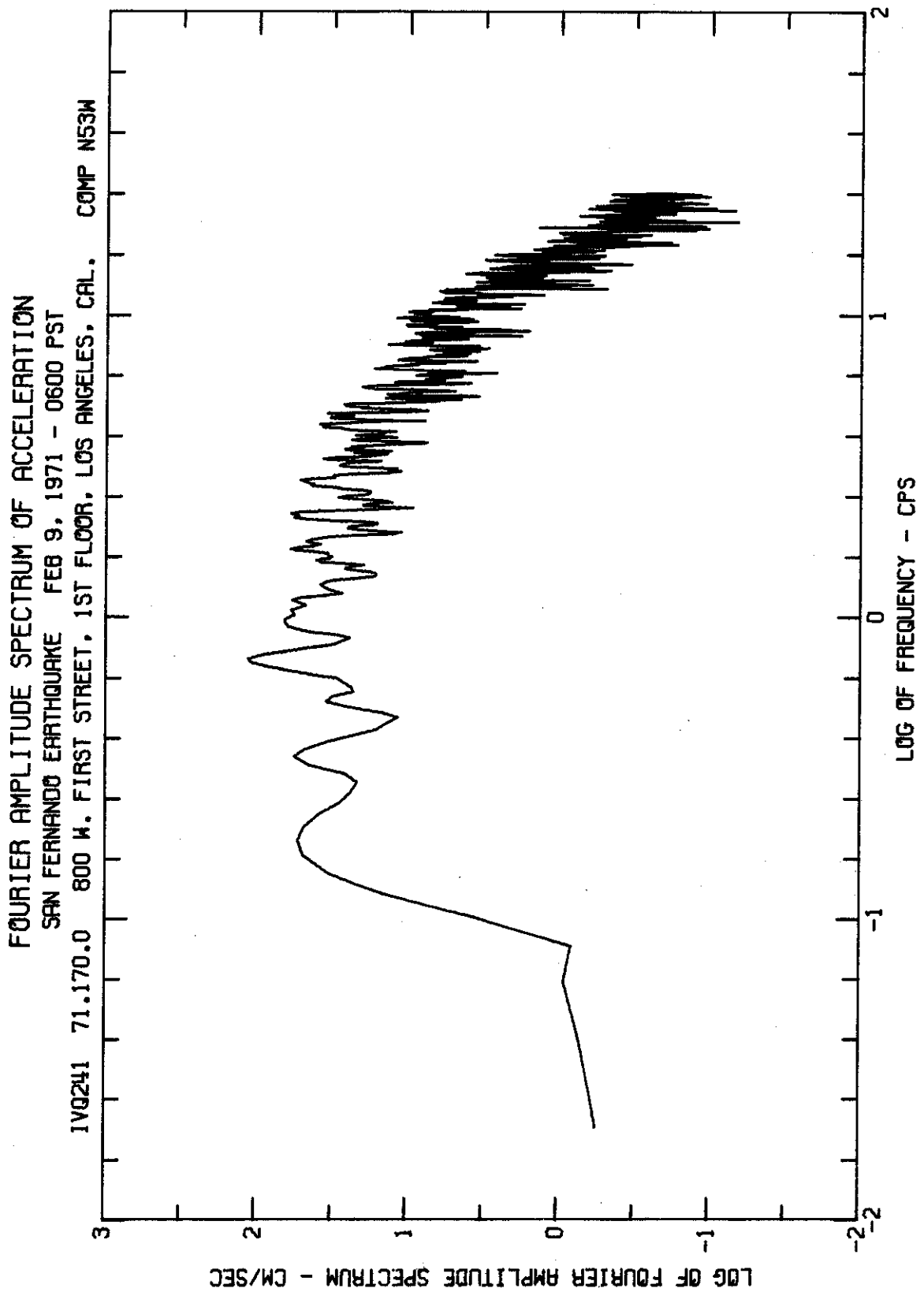








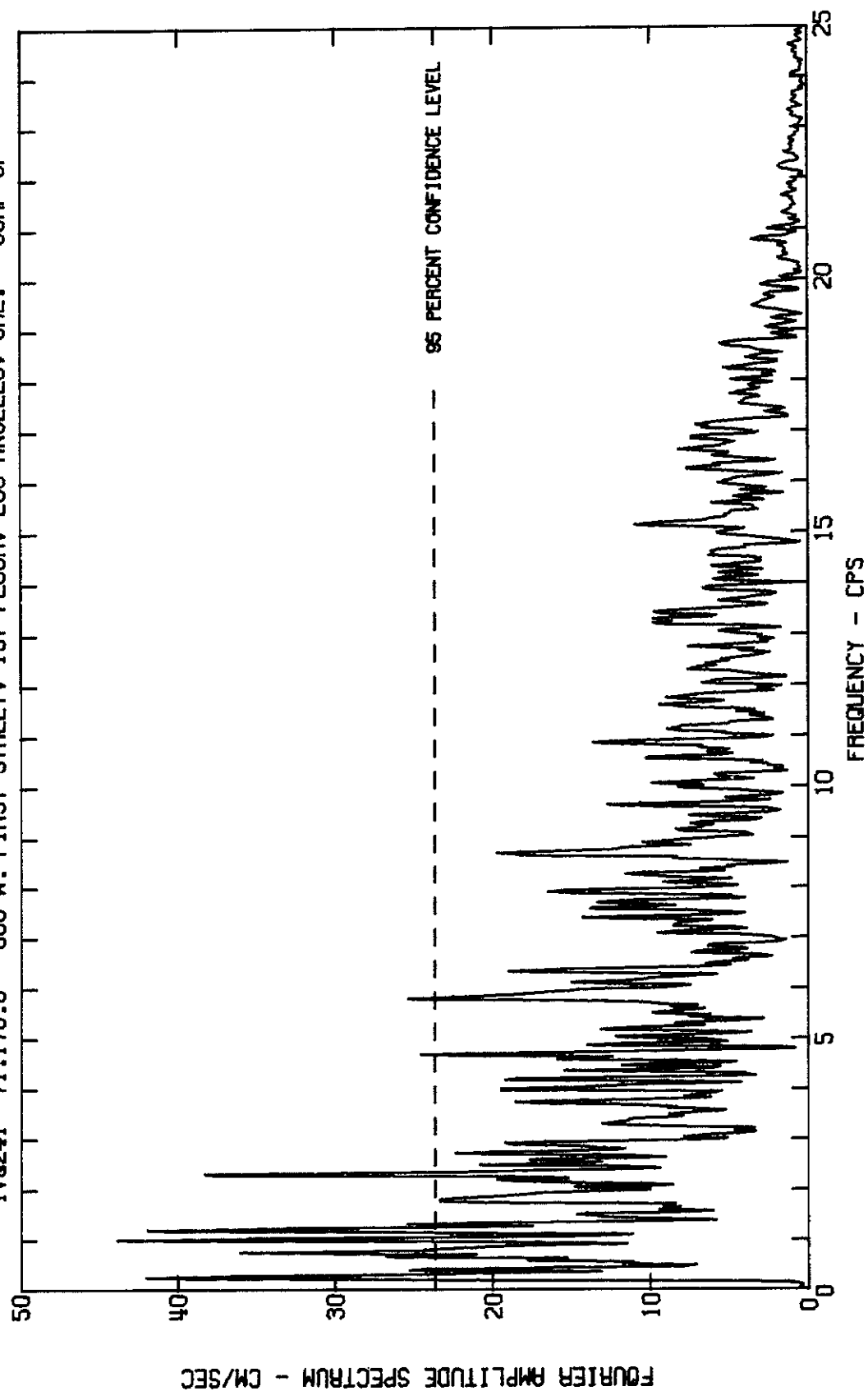


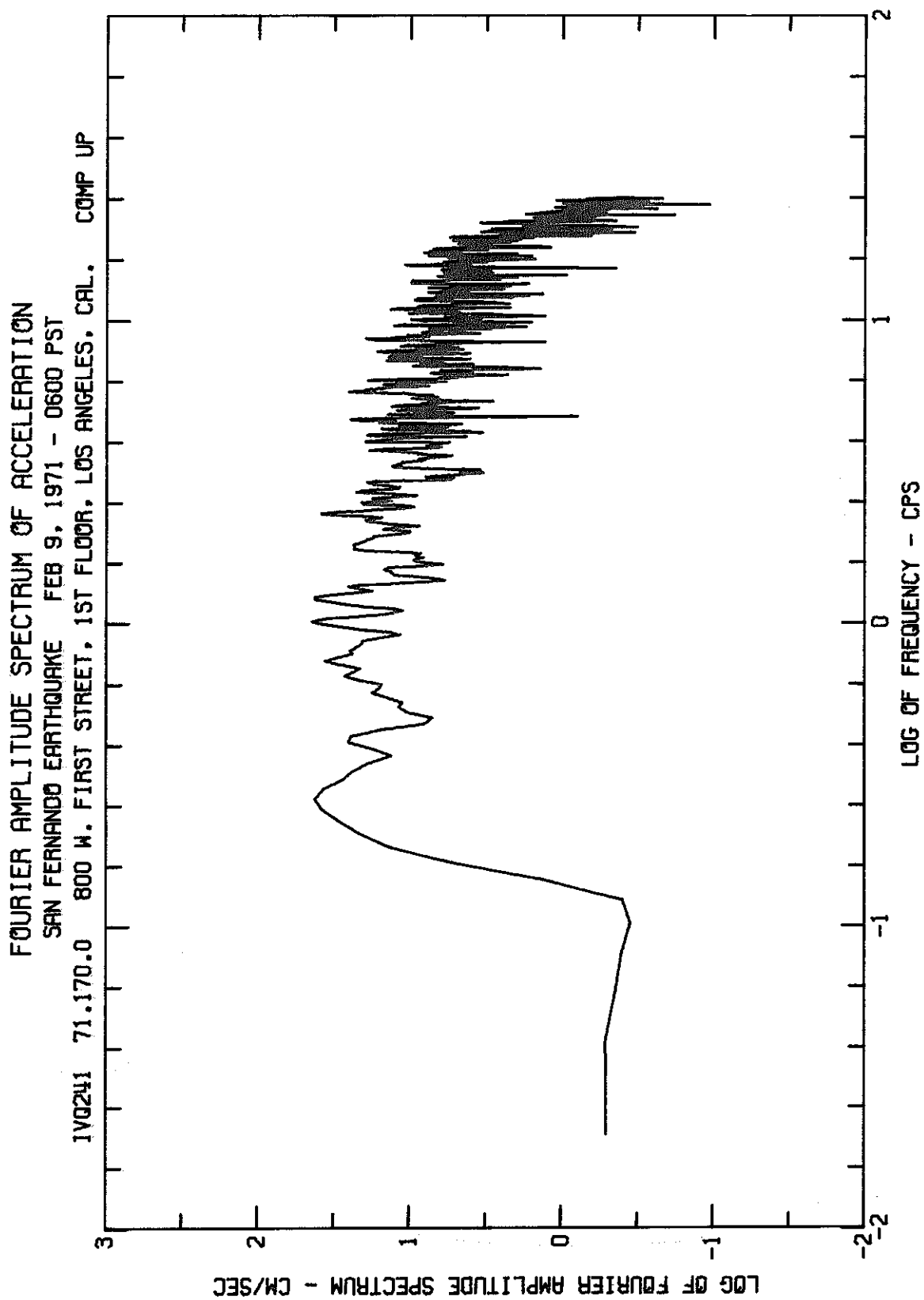


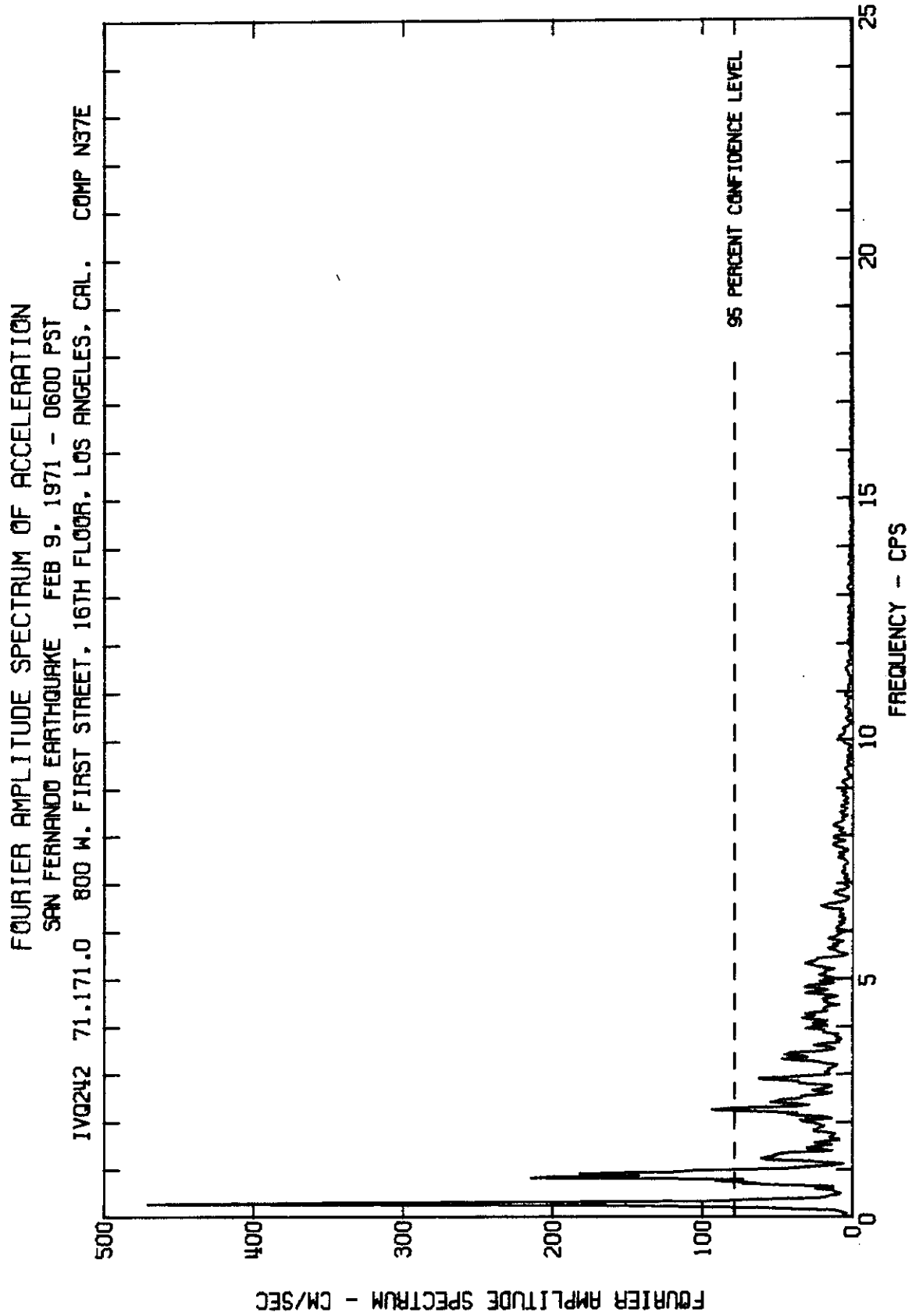
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SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

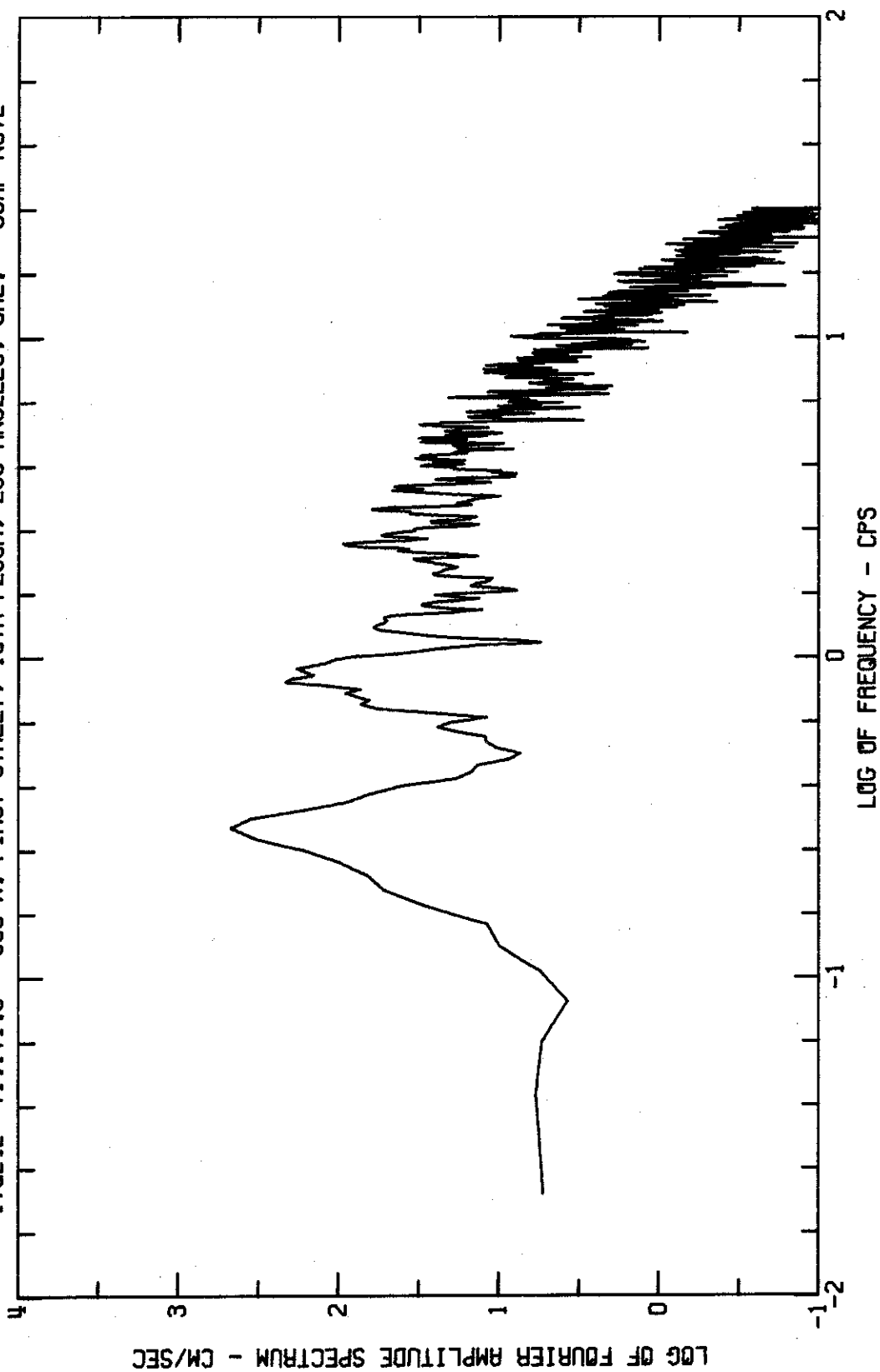
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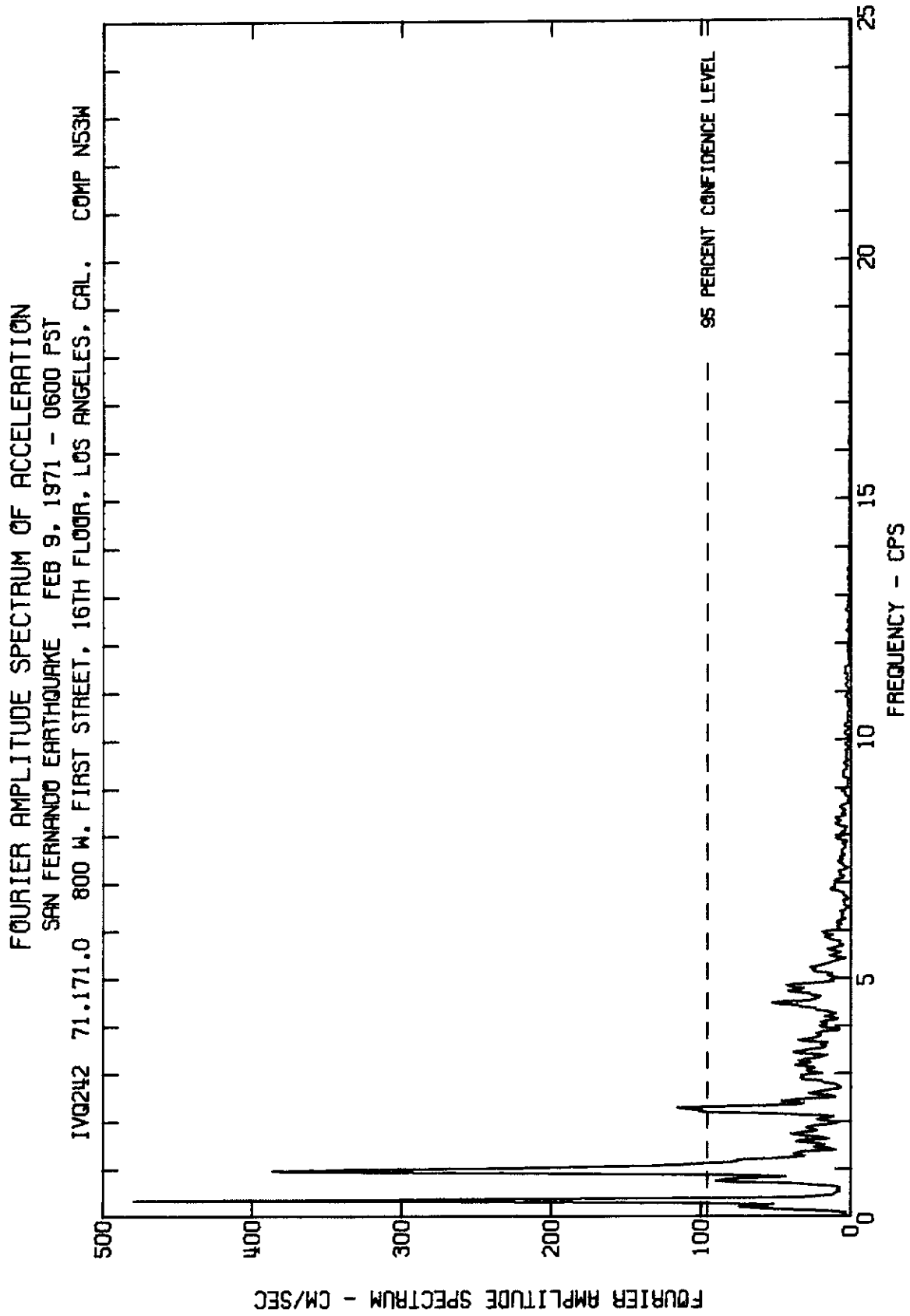


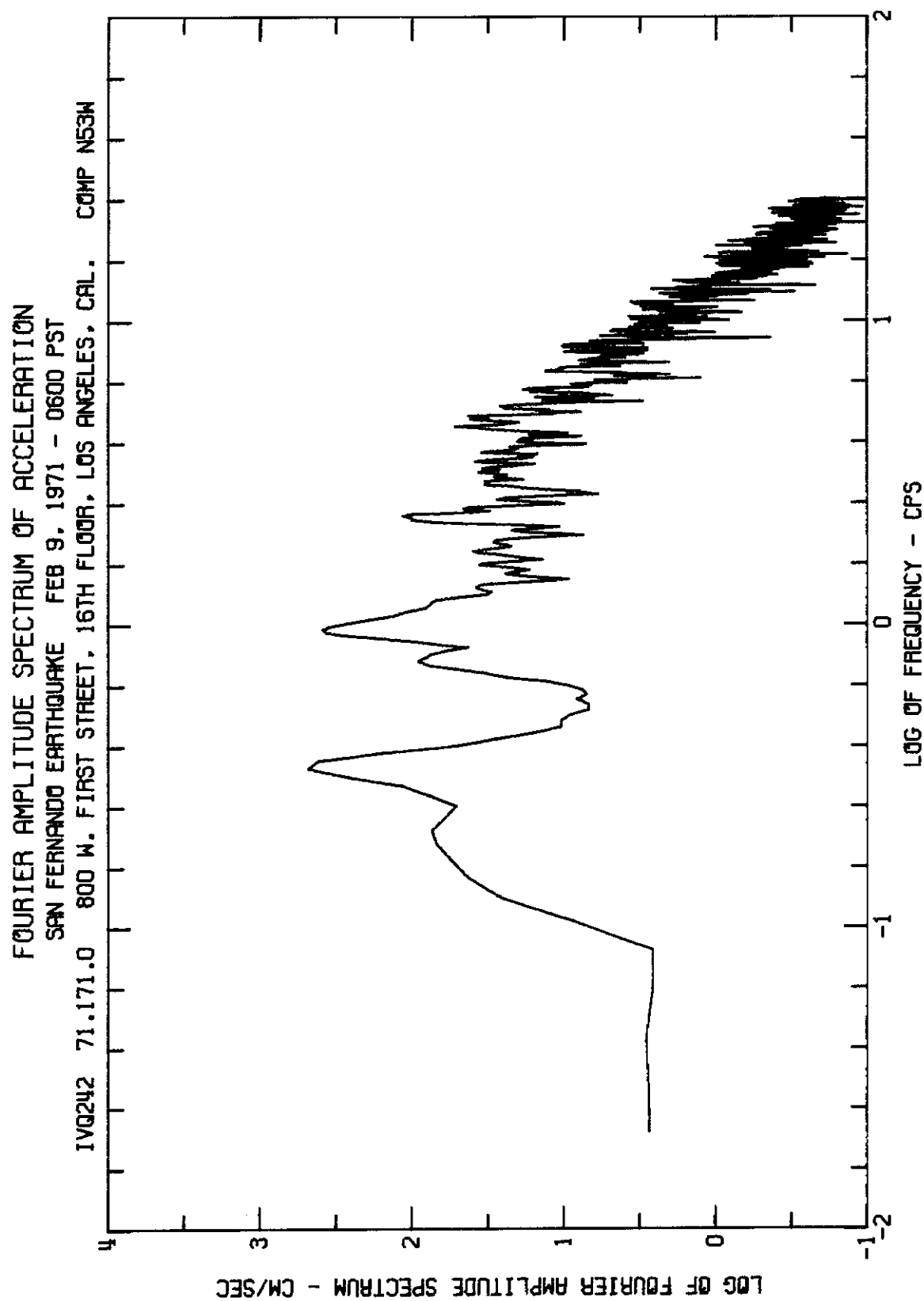


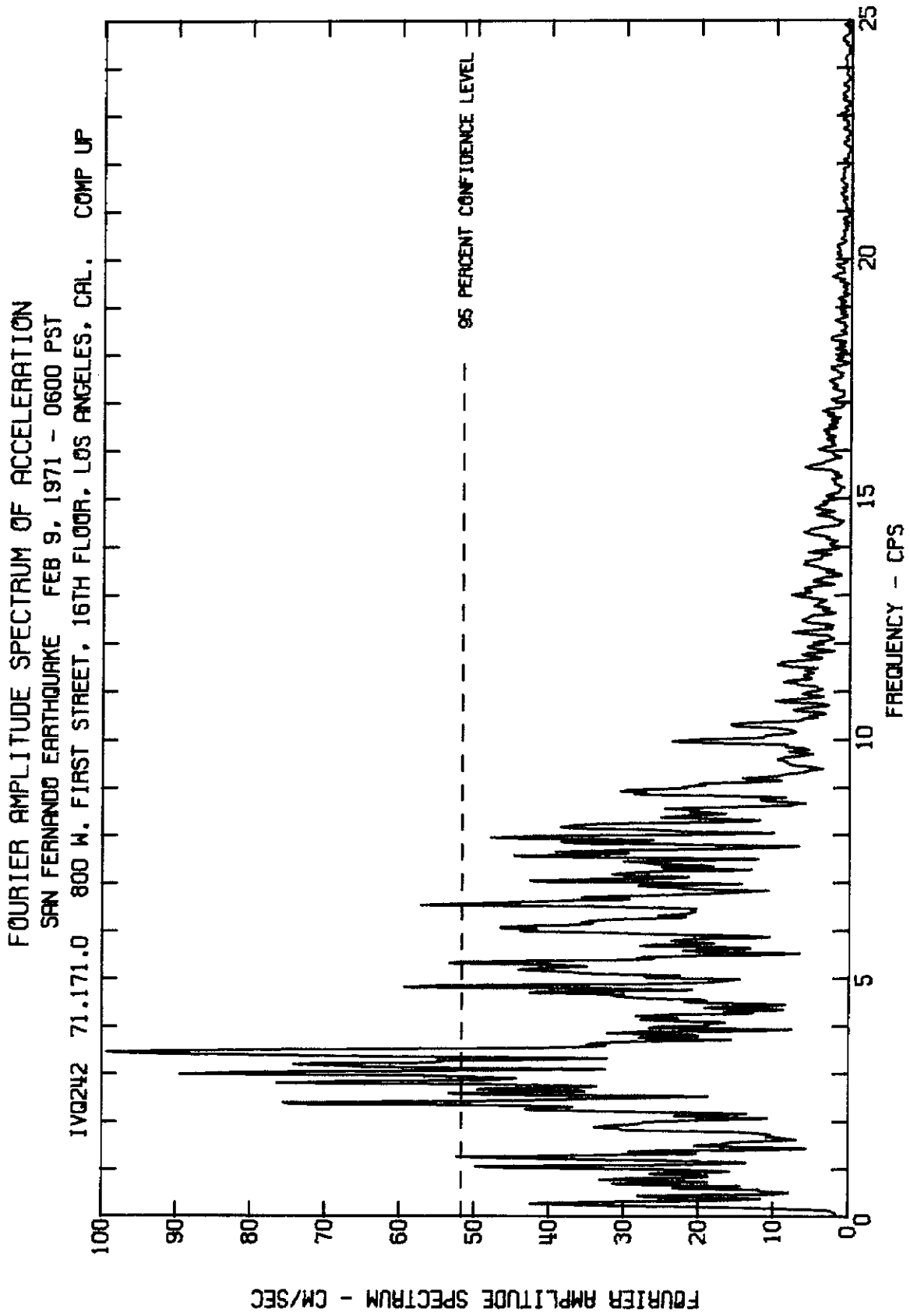


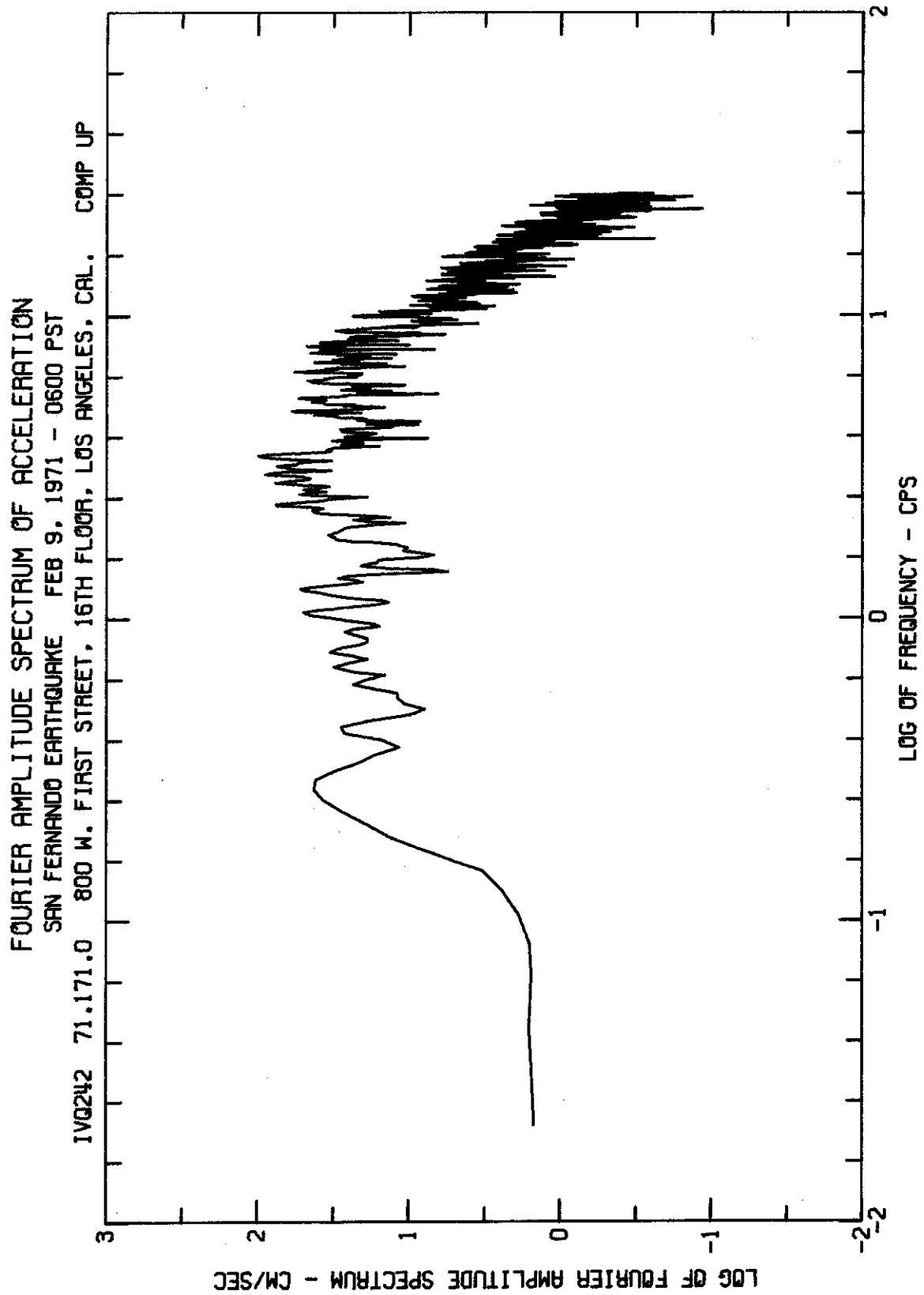
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SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST
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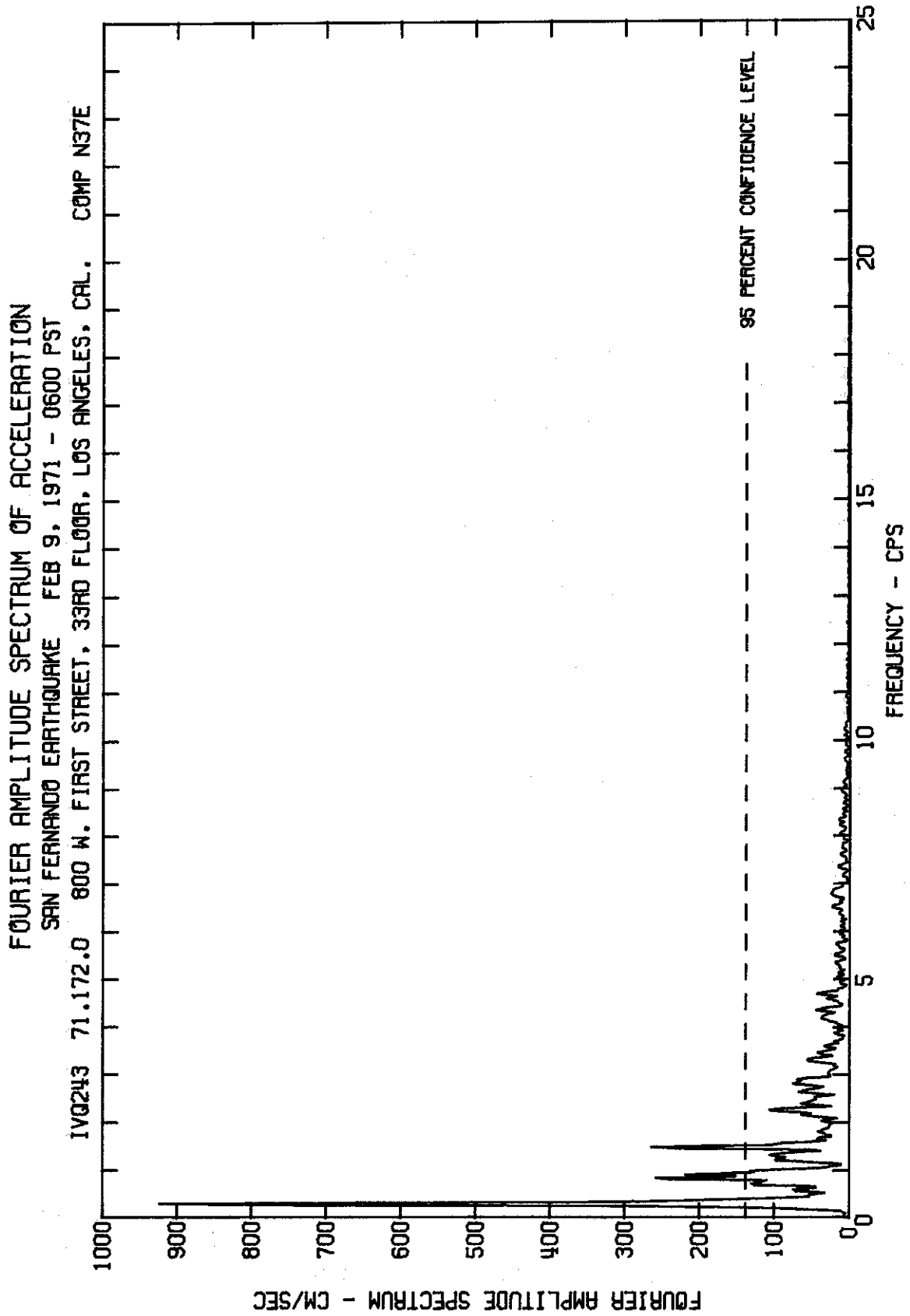


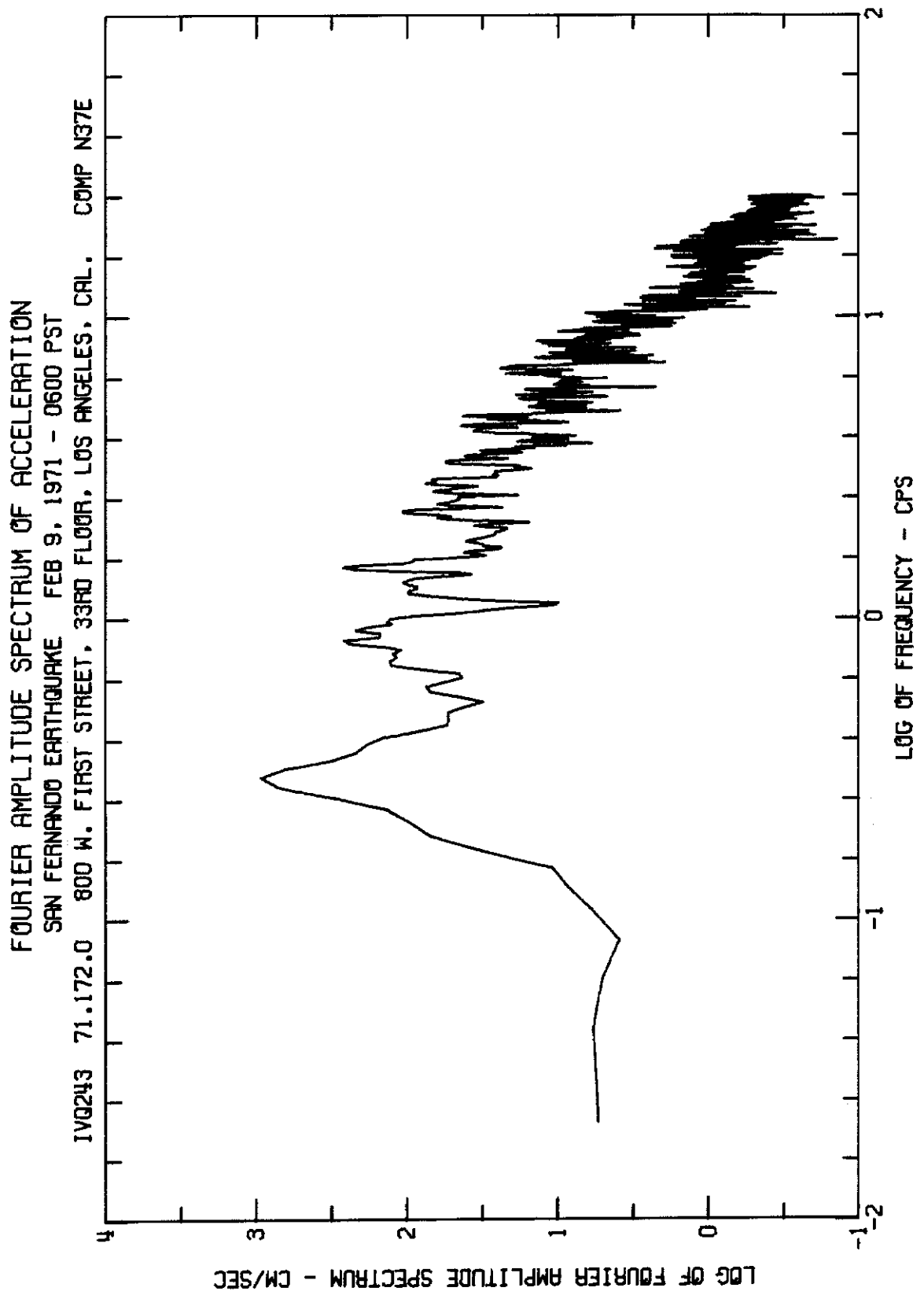


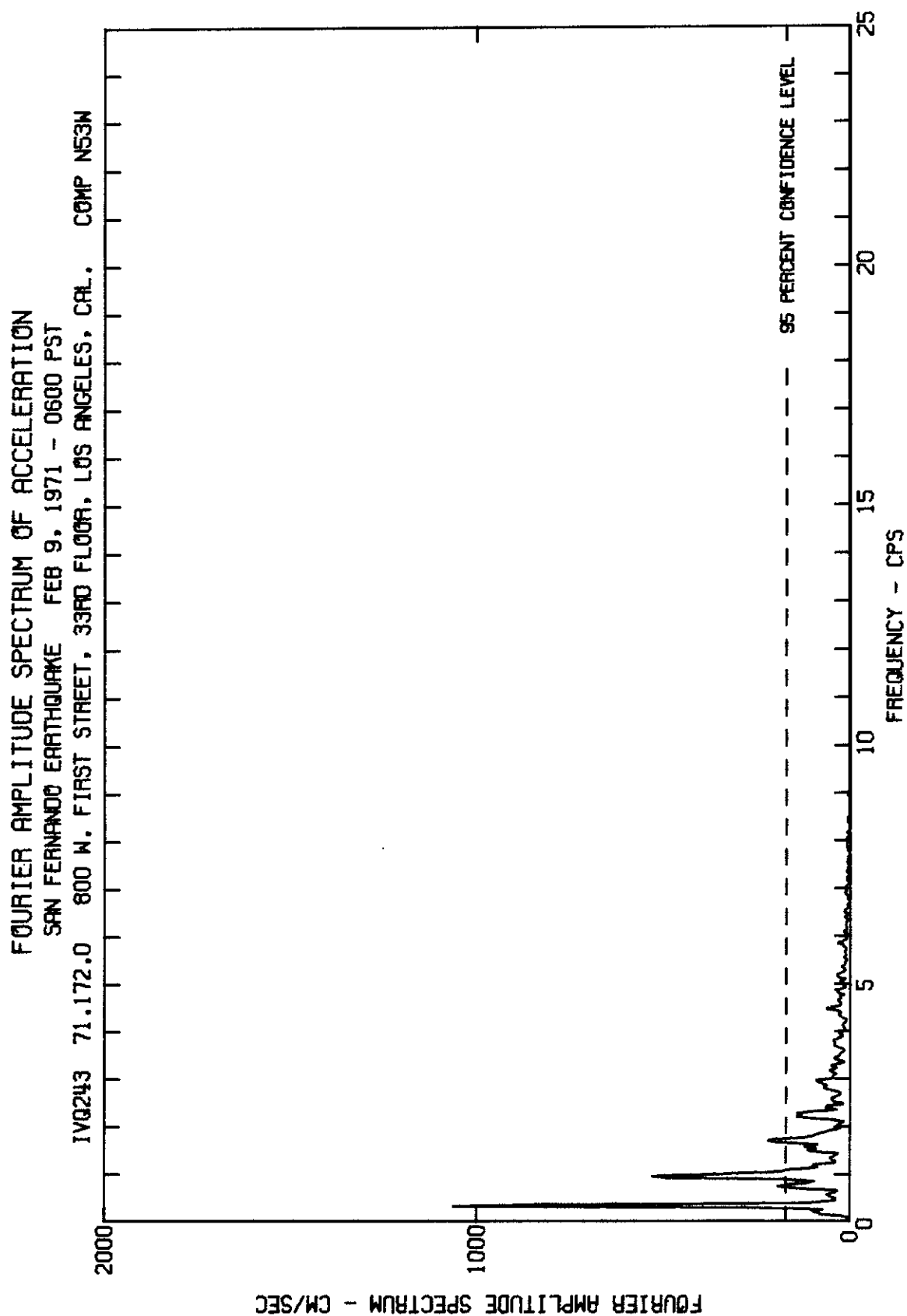








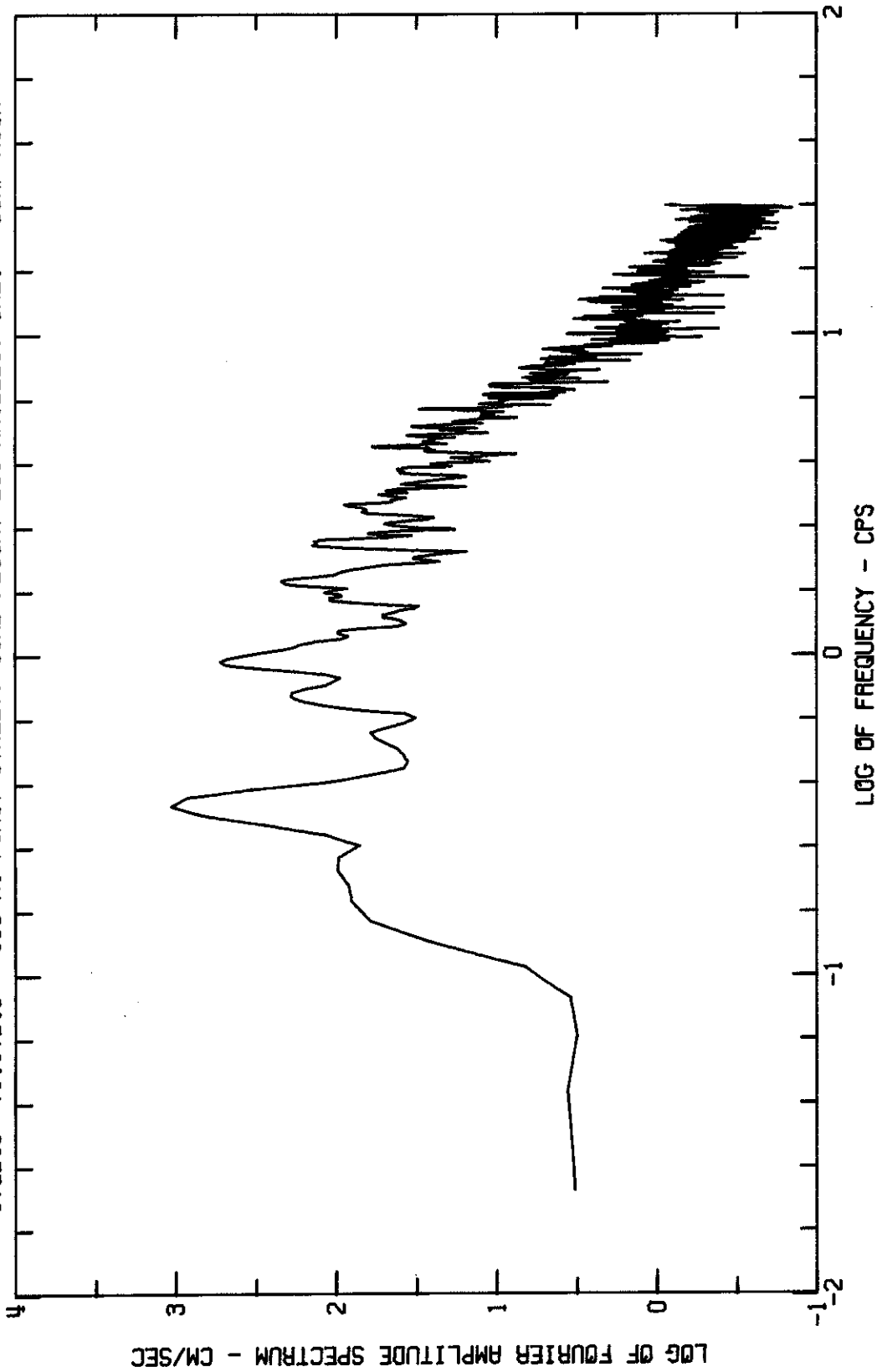


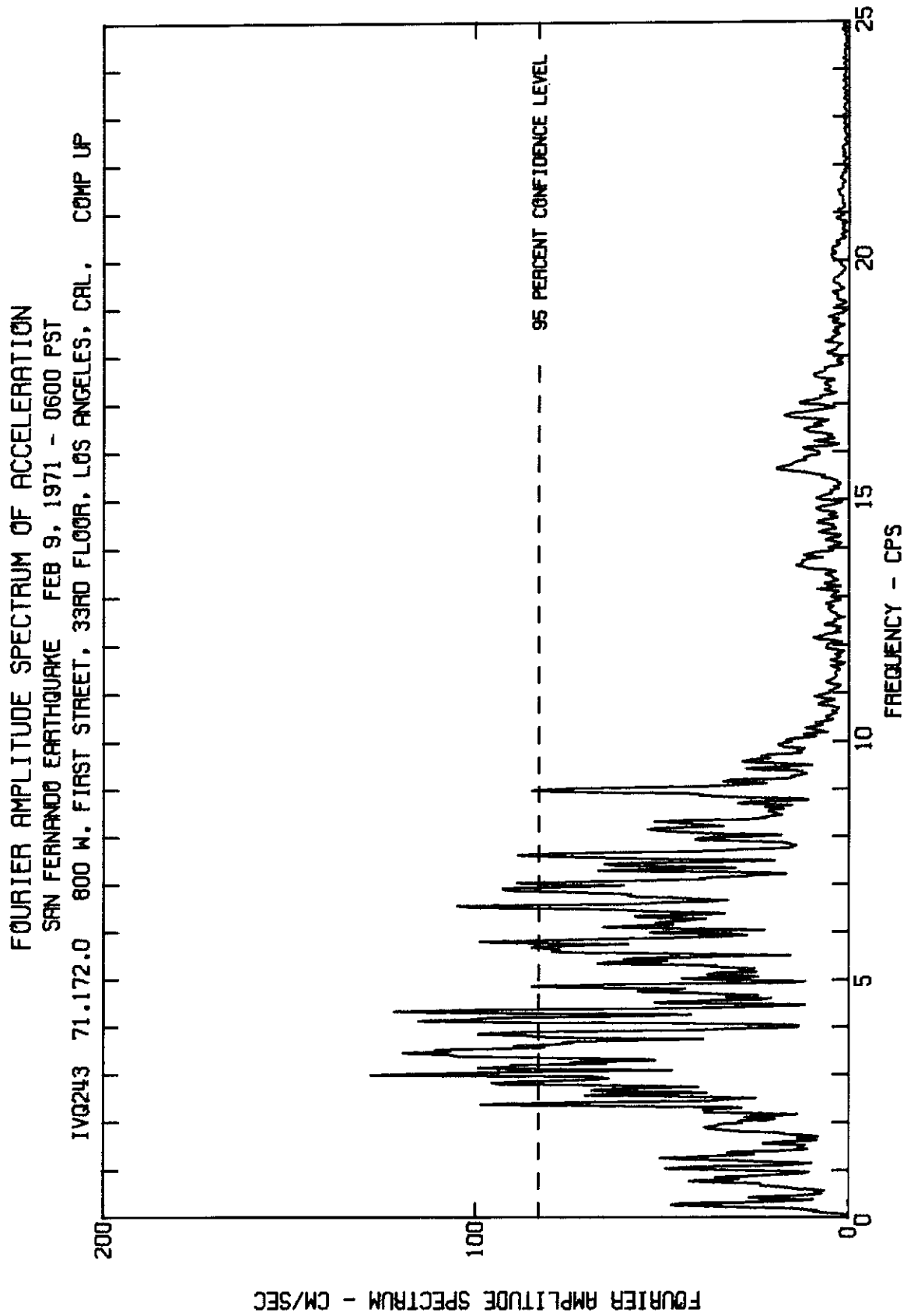


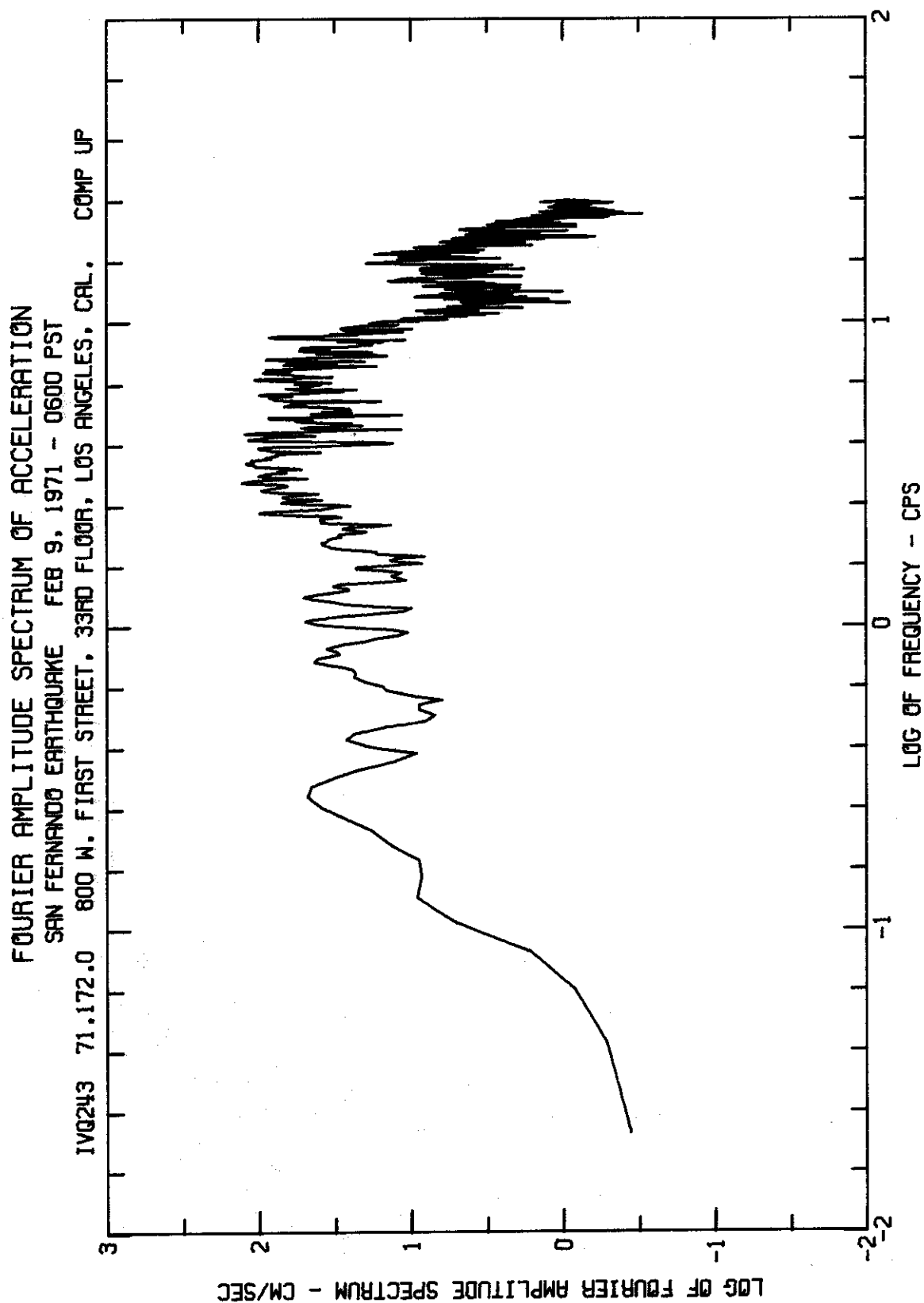
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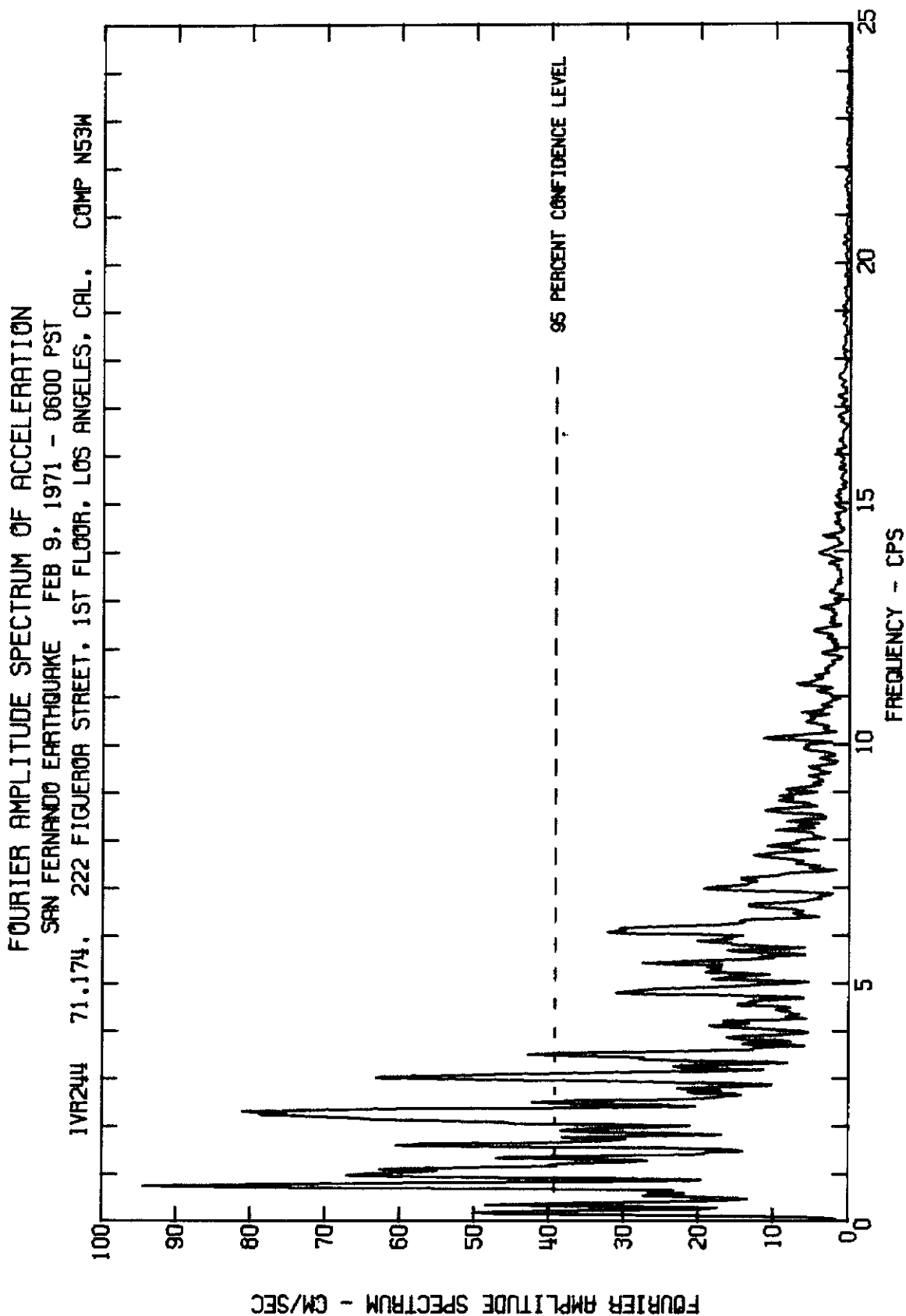
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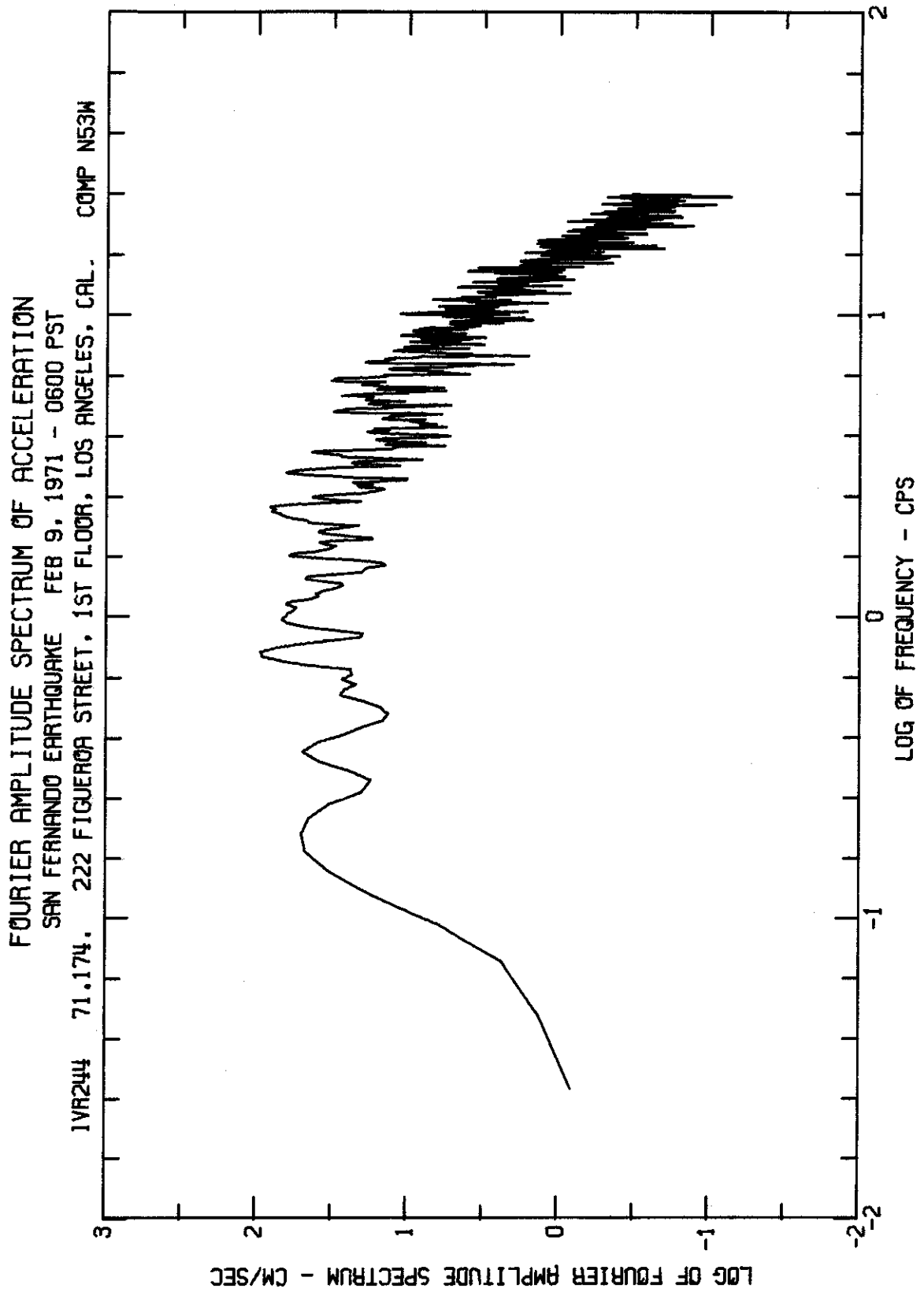
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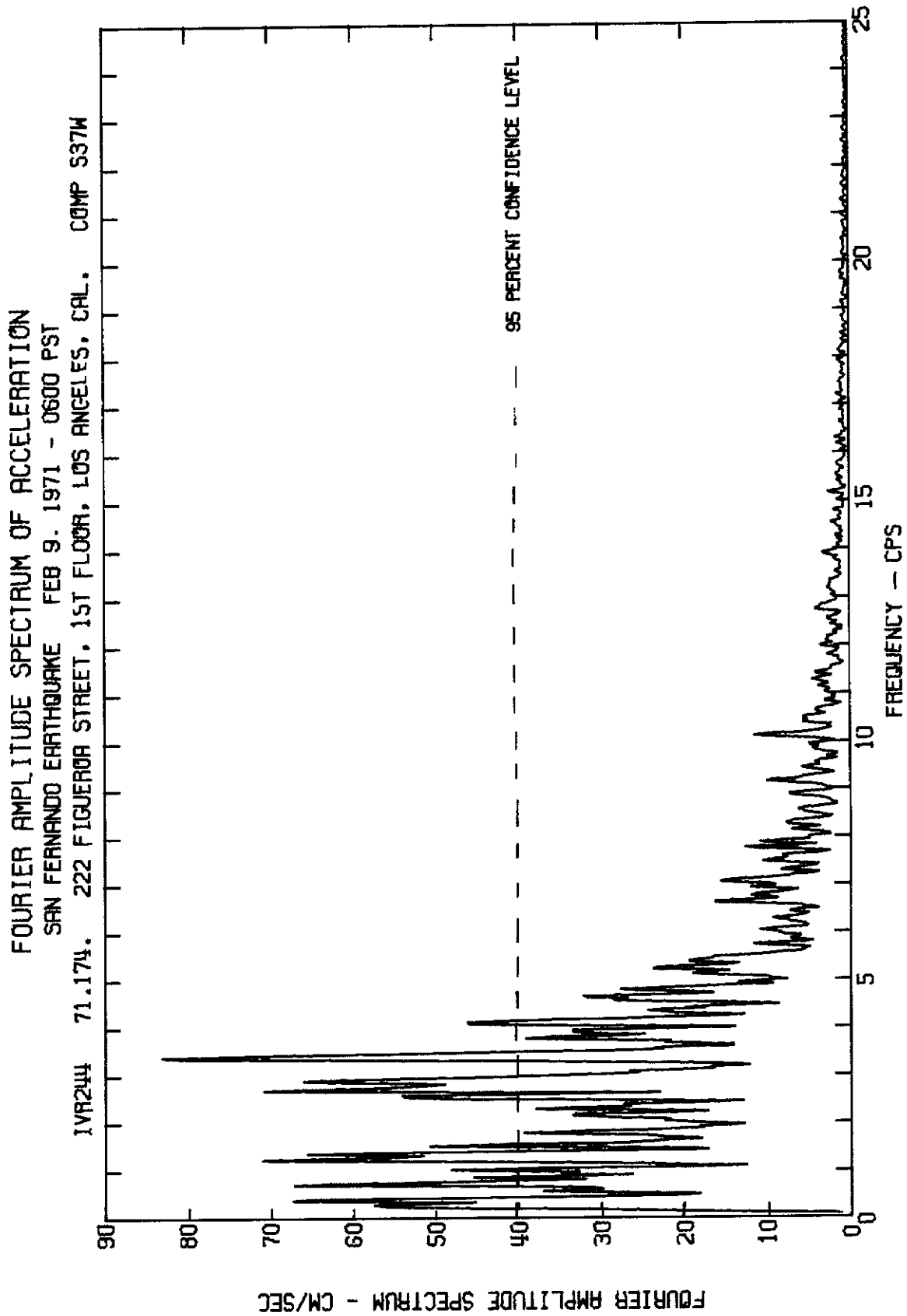


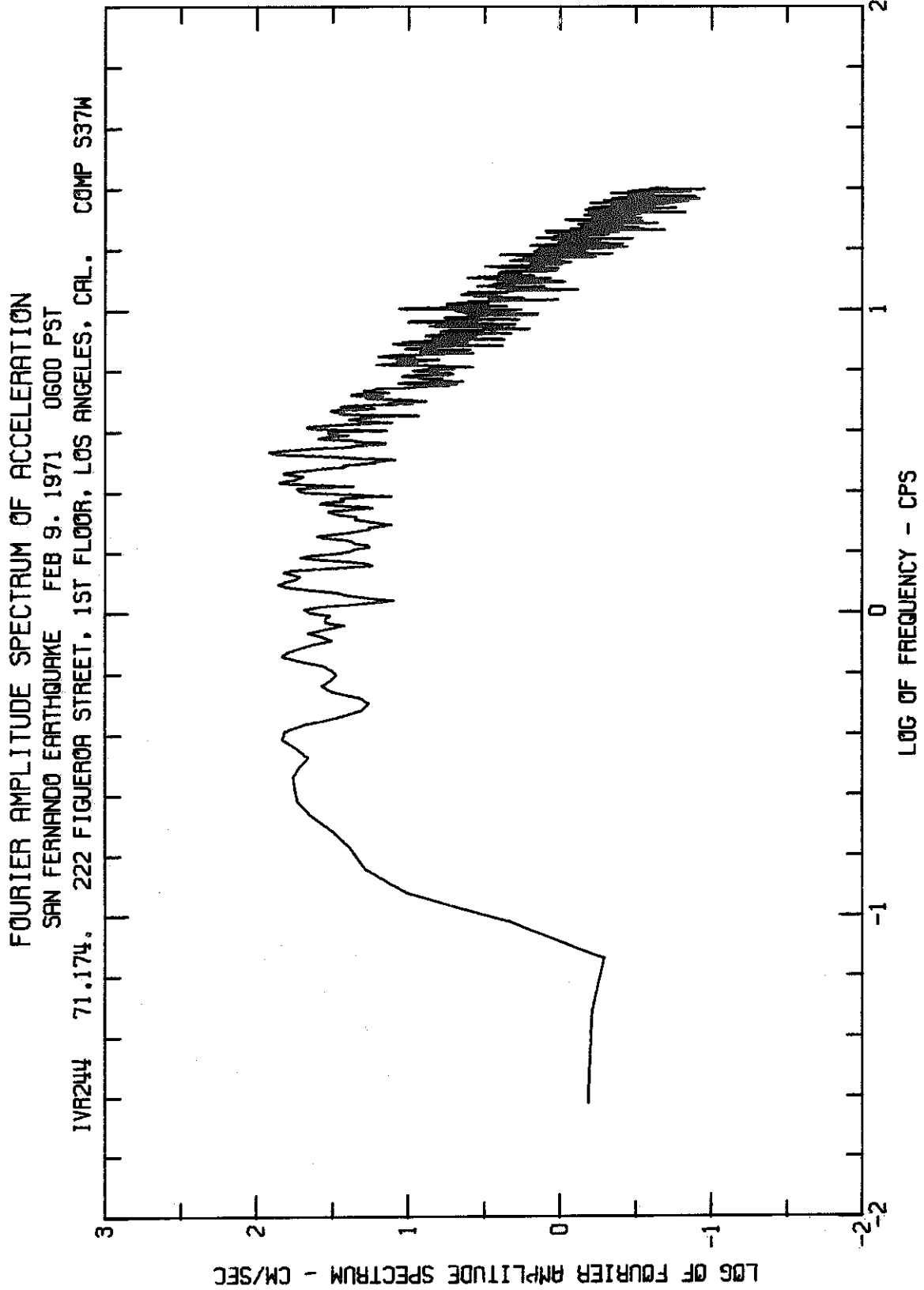


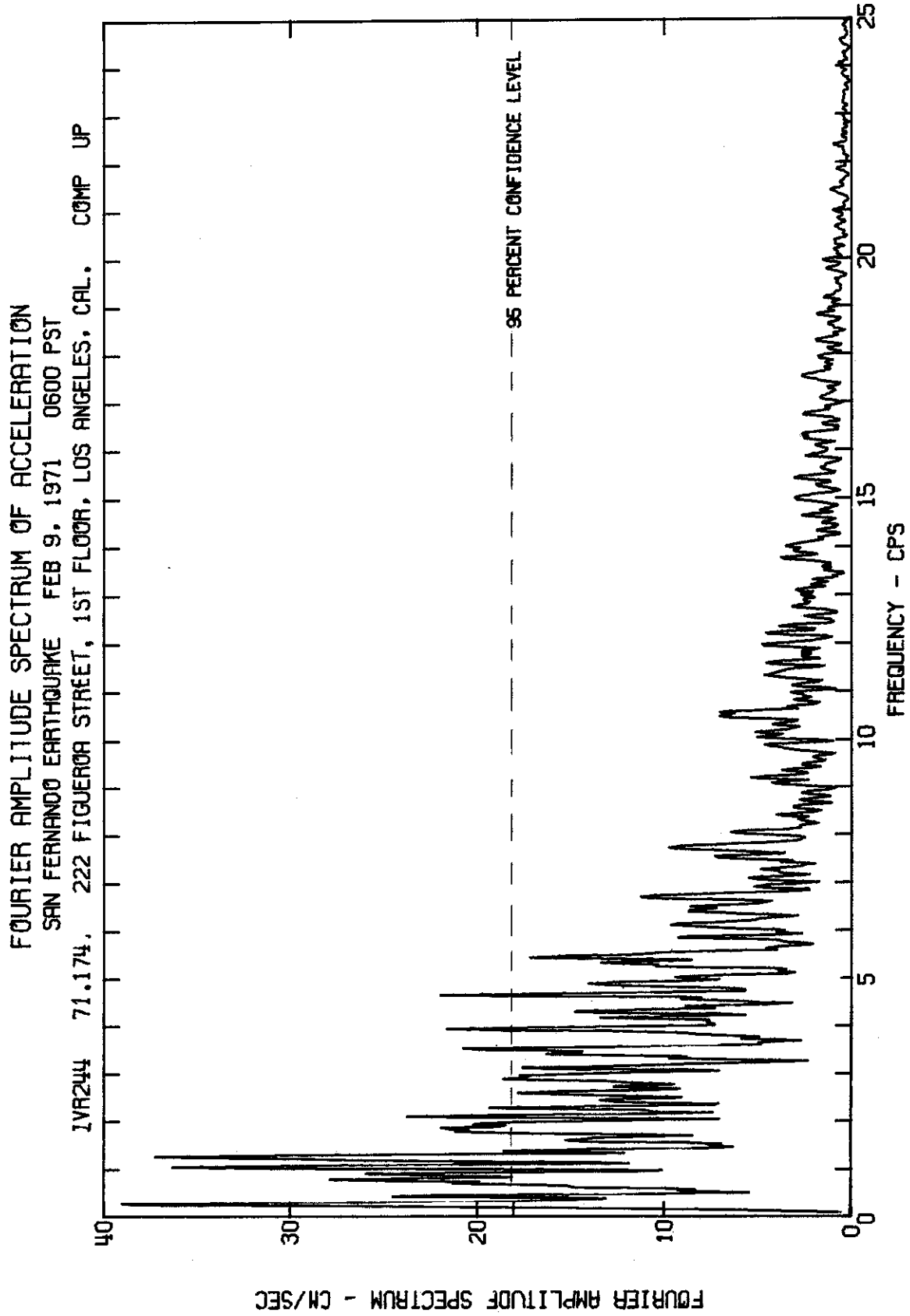


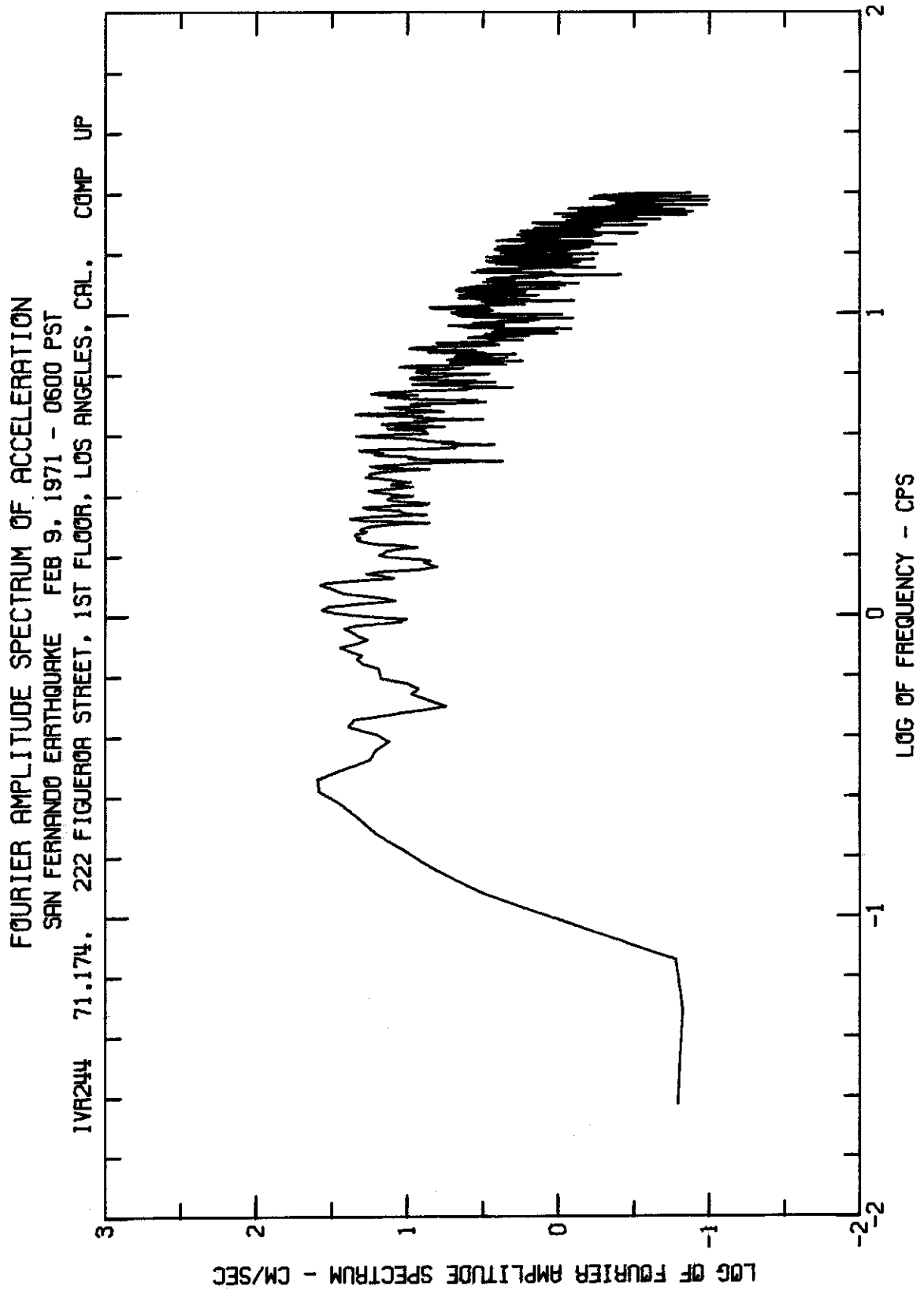


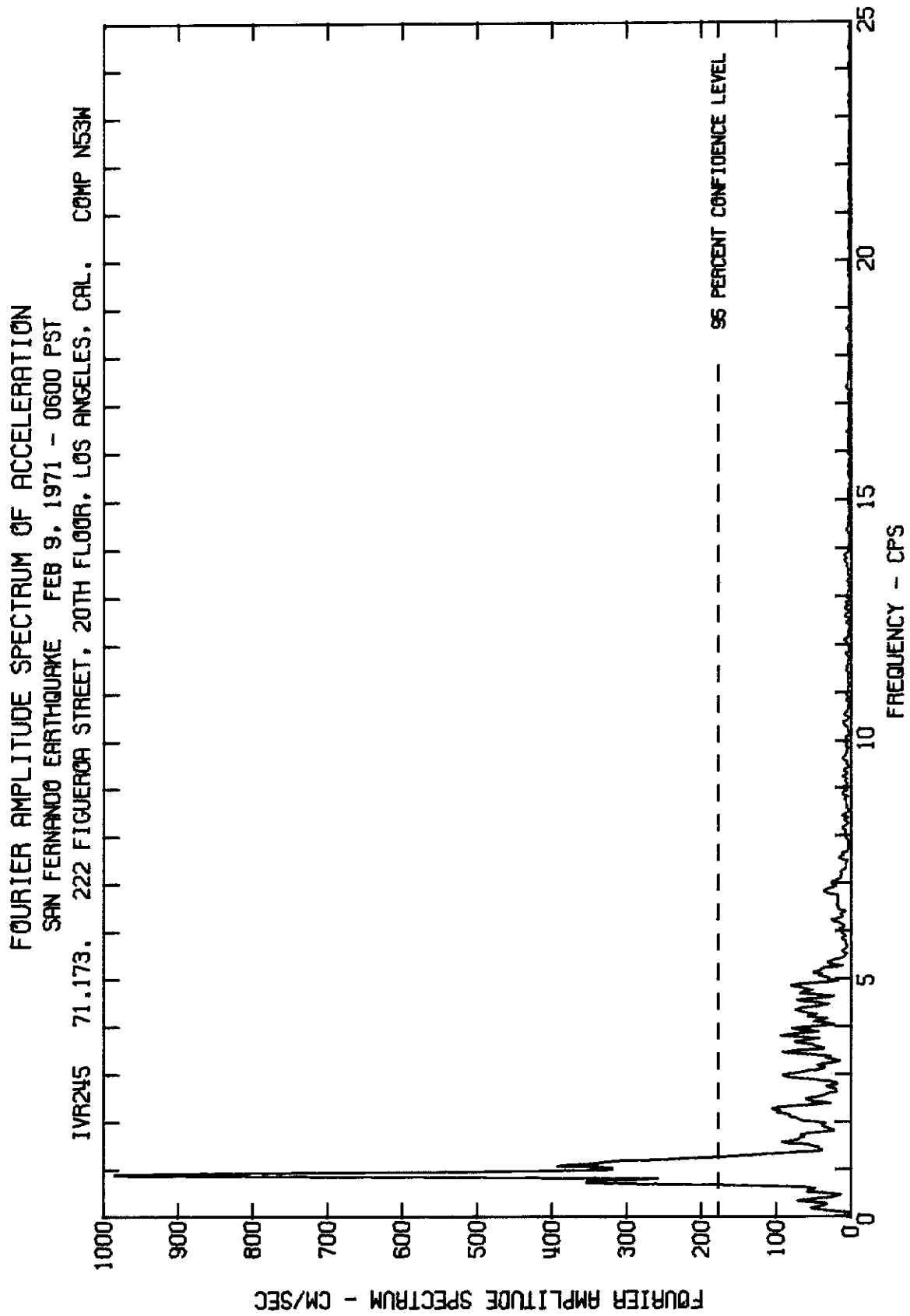


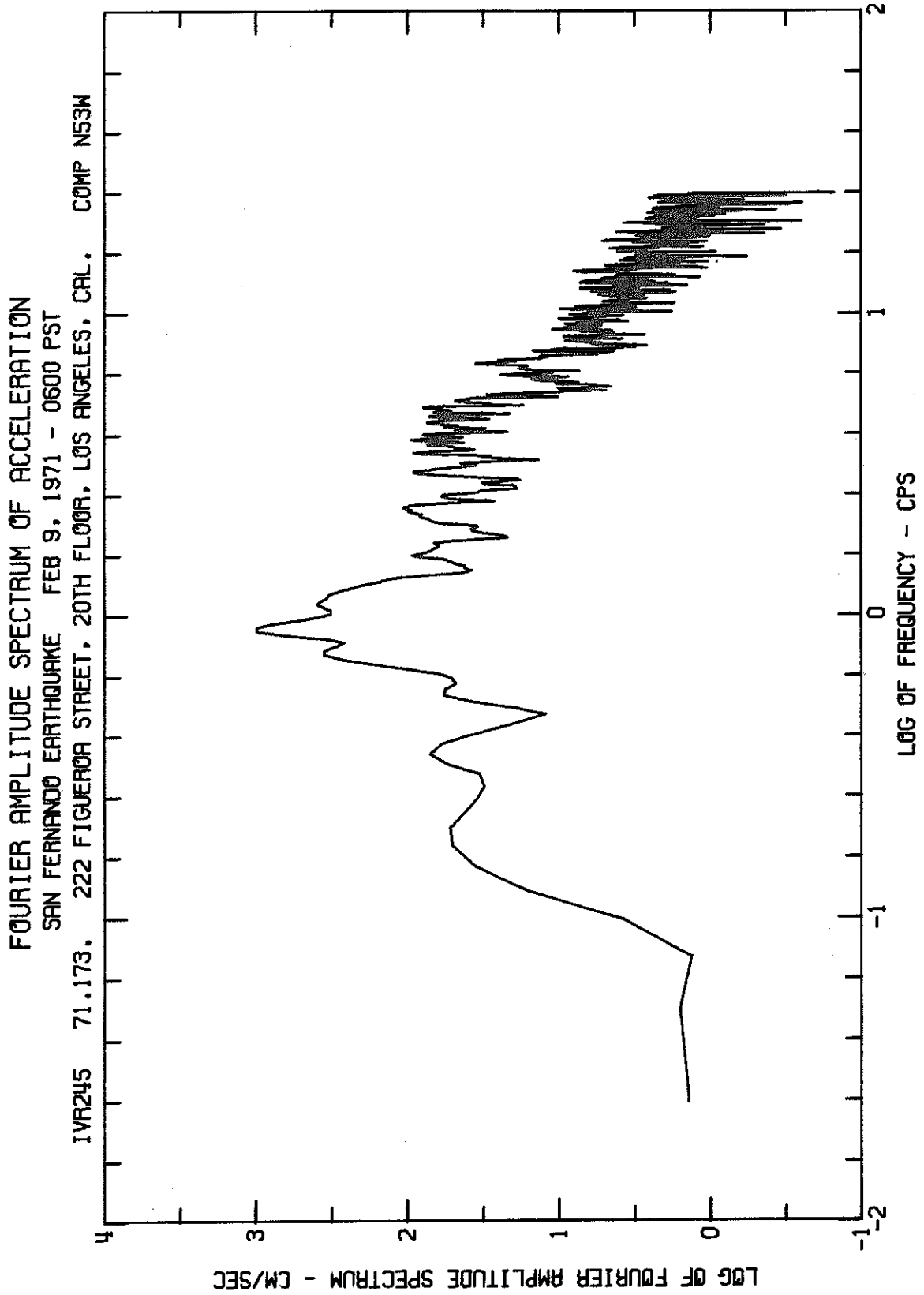


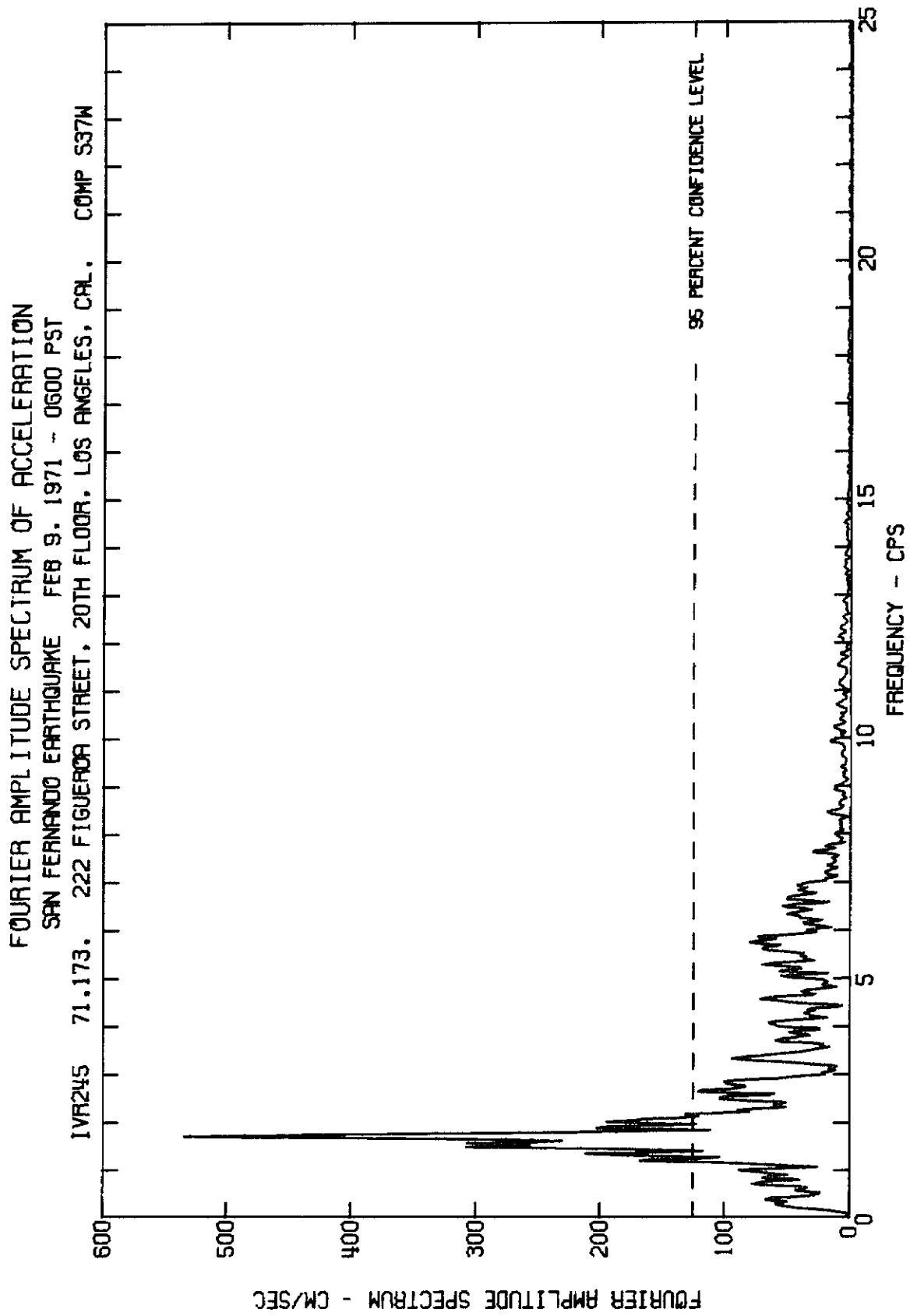


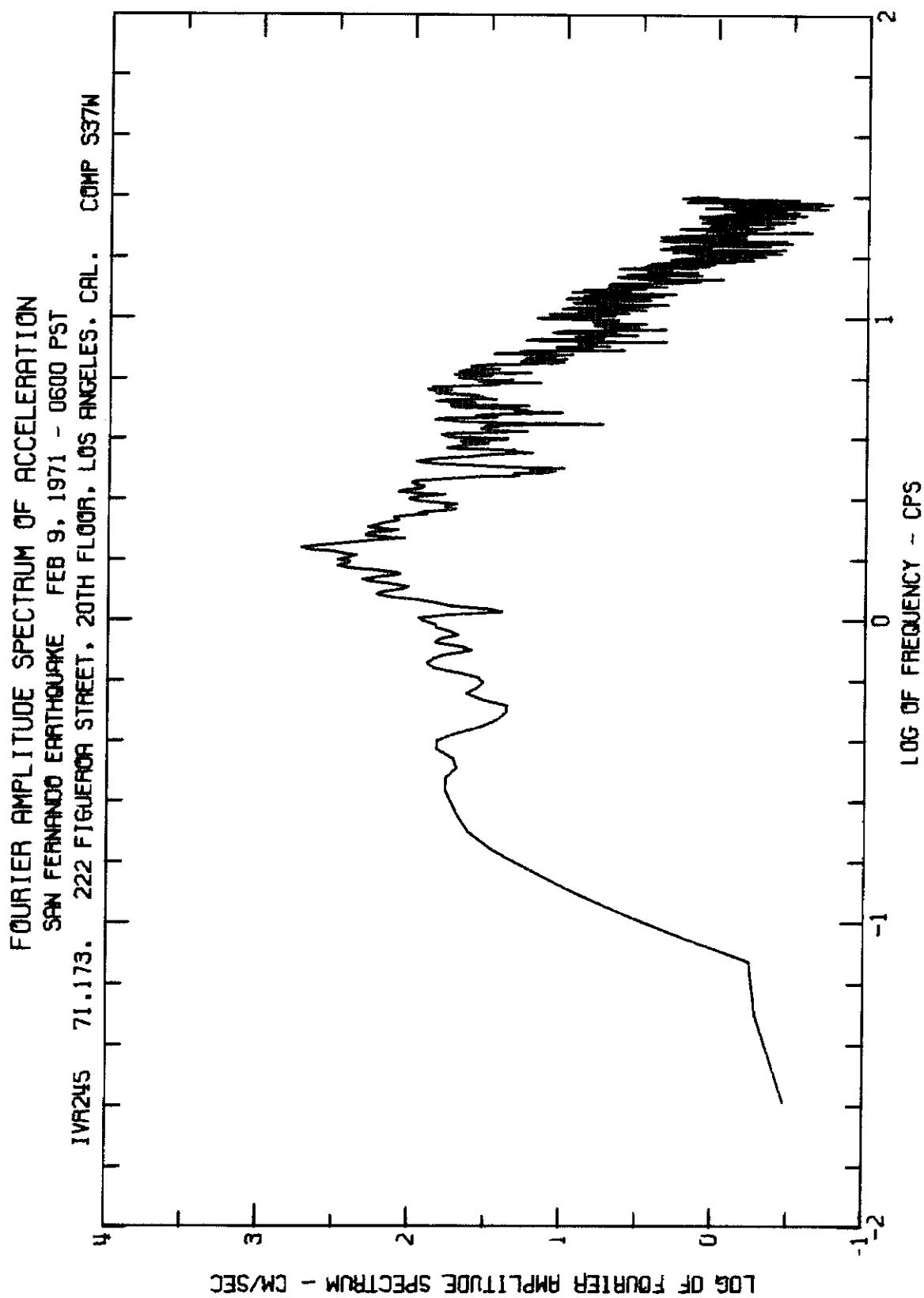


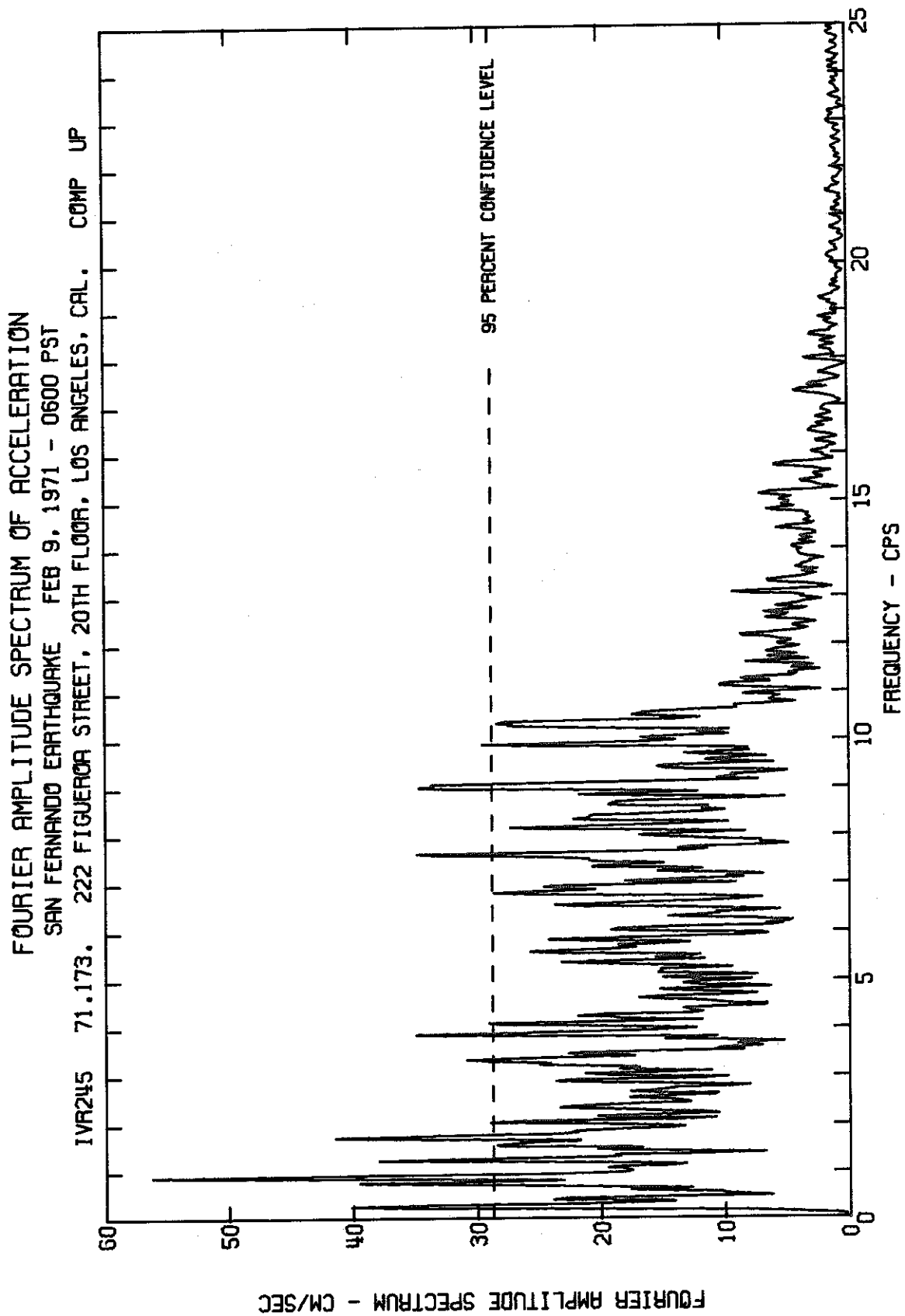


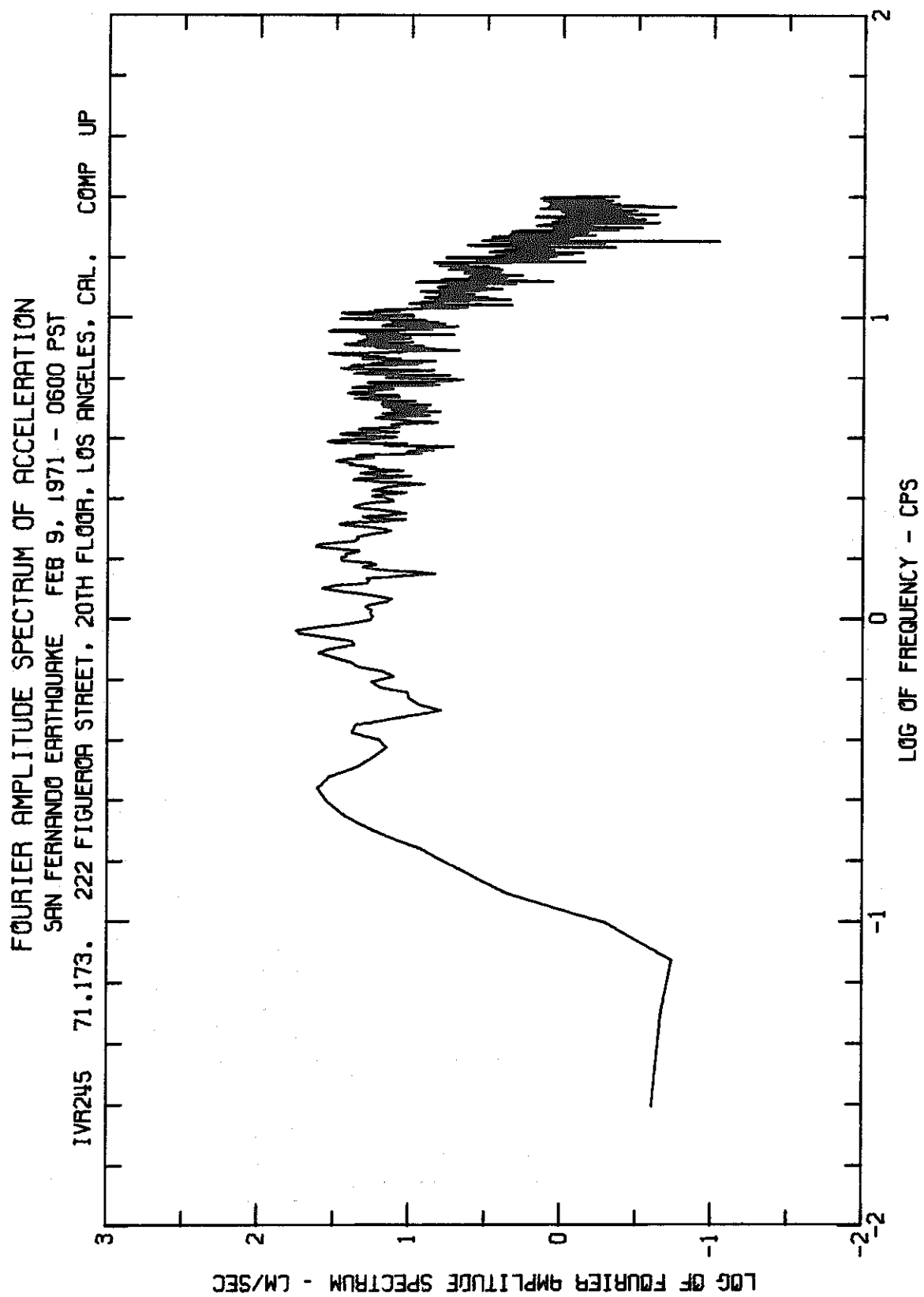


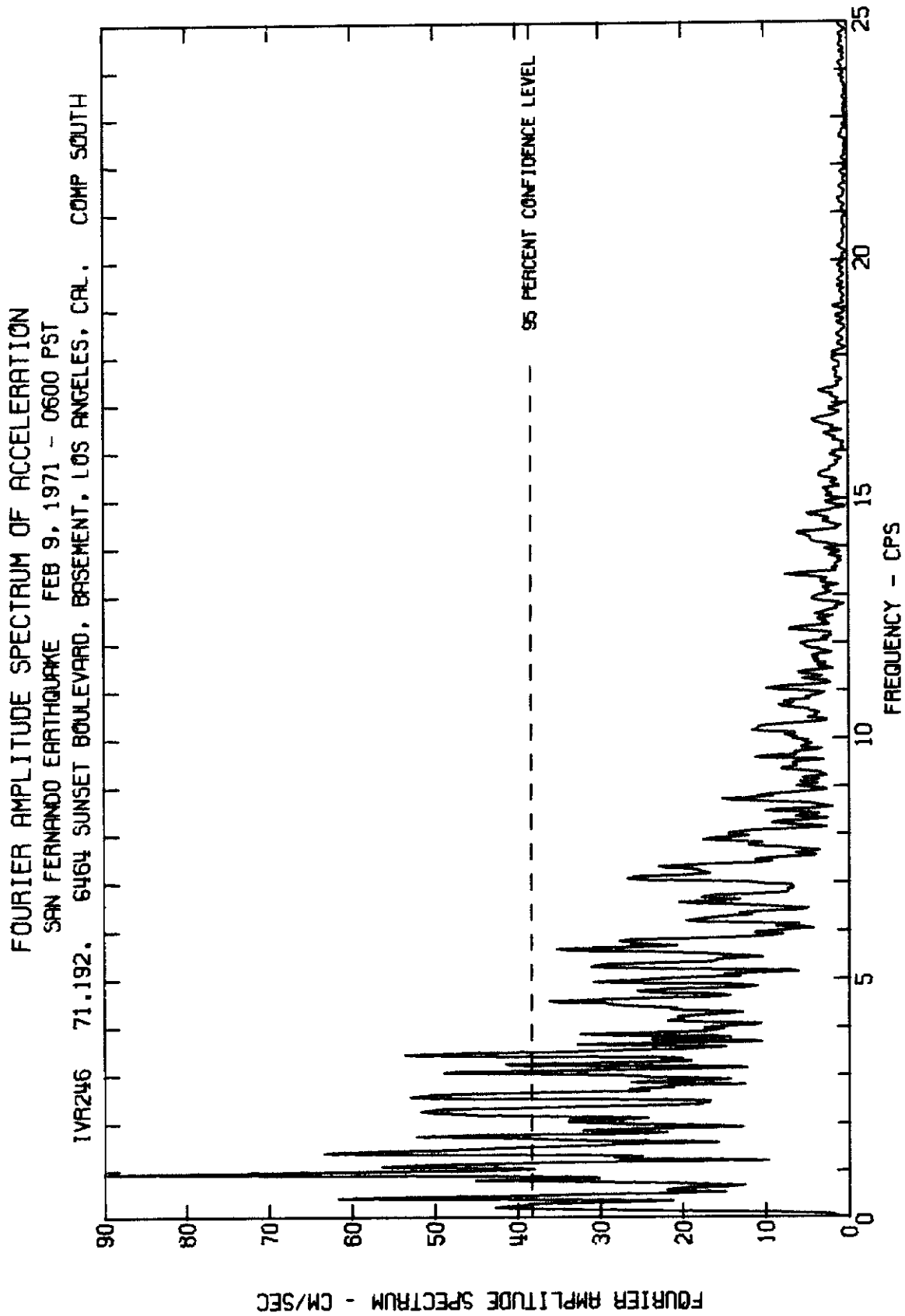




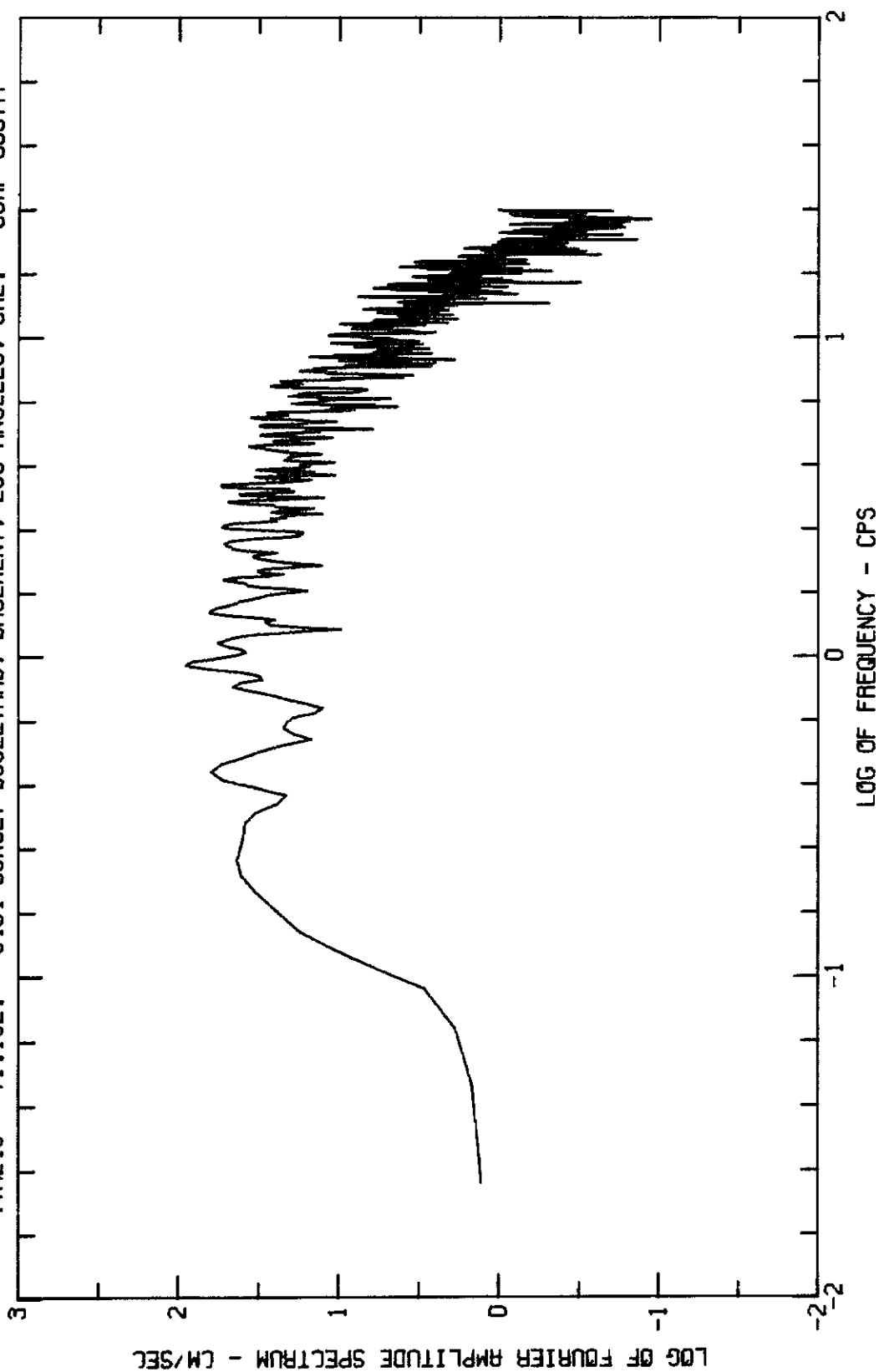


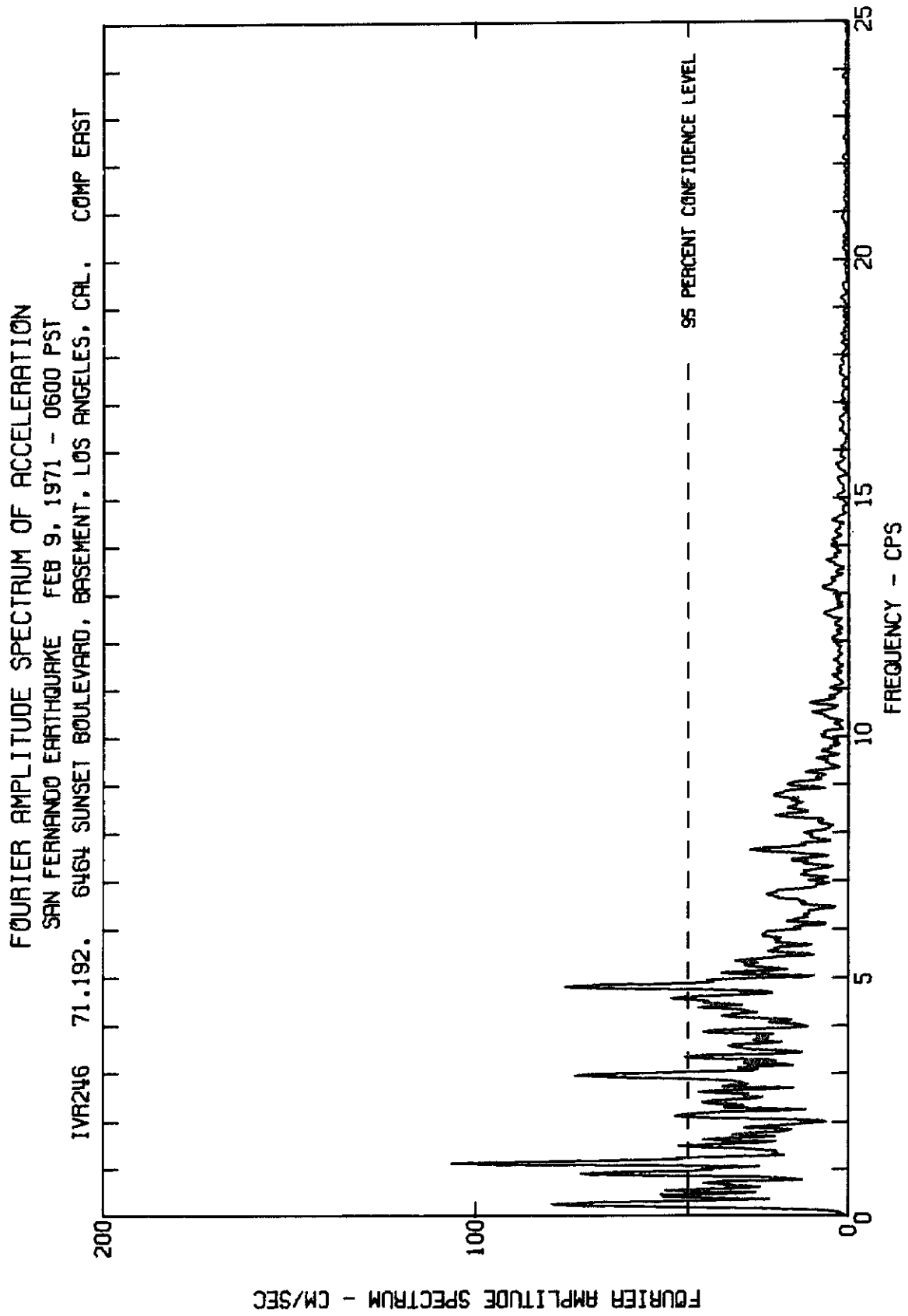


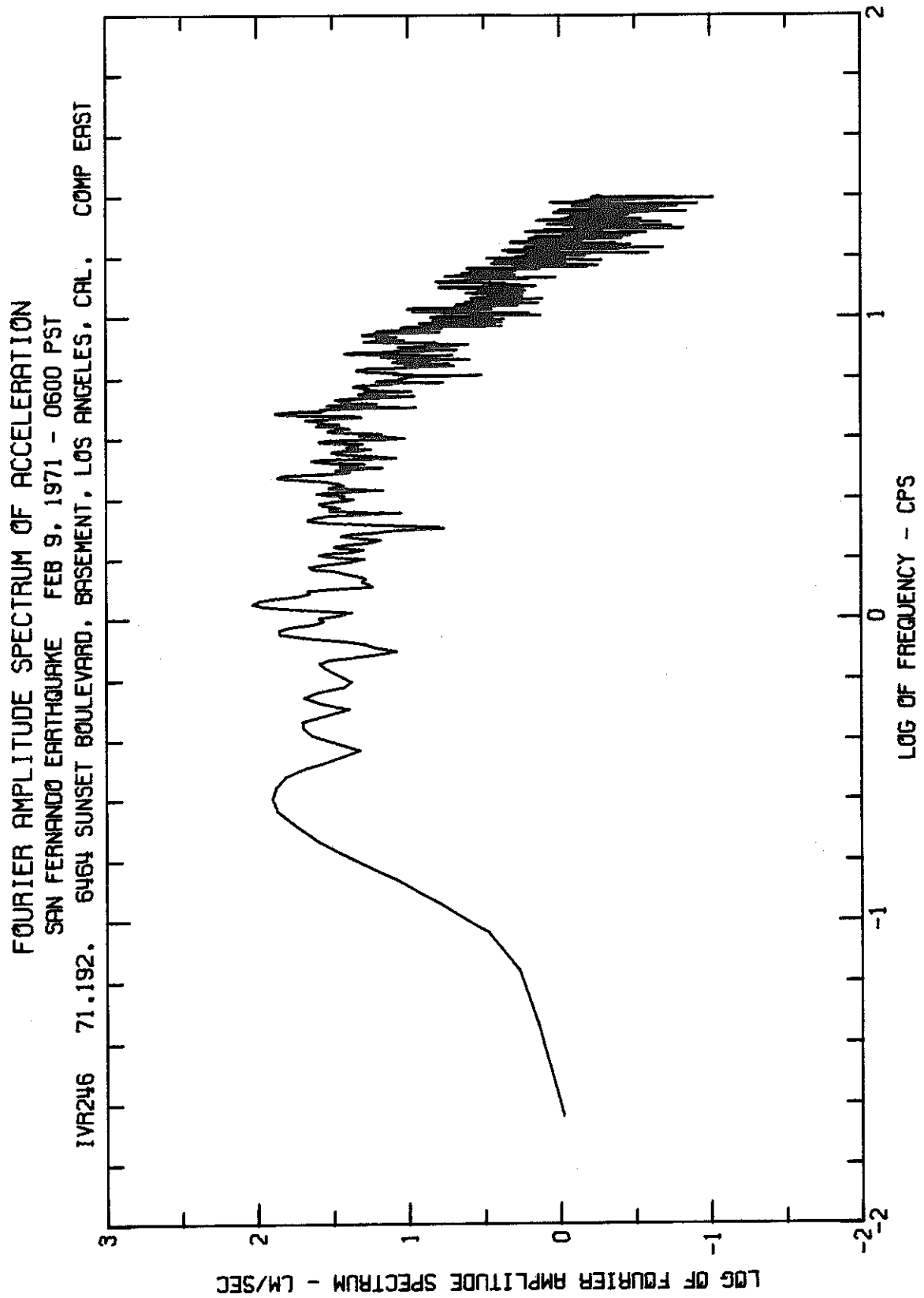


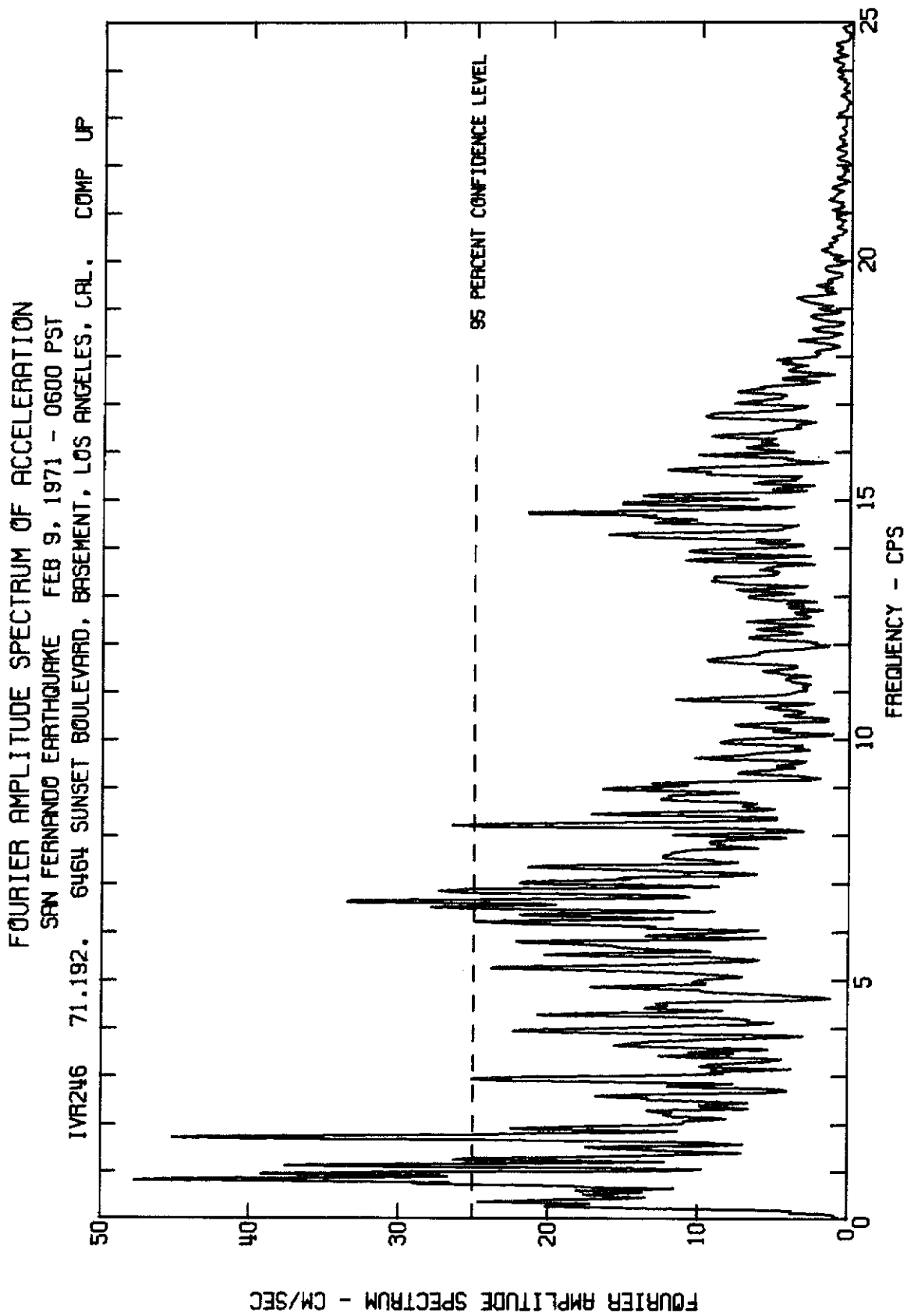


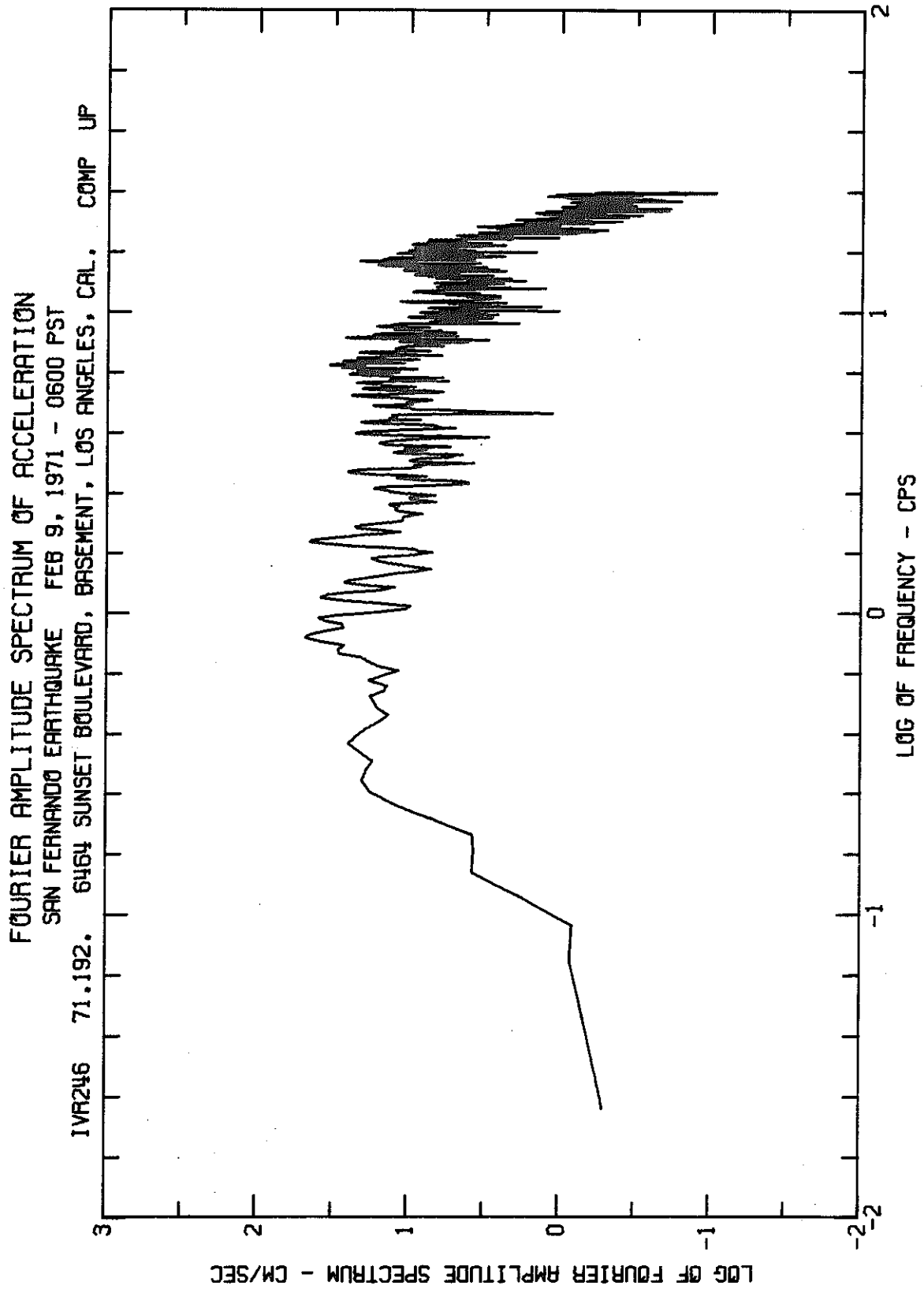
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST
1VR246 71.192. 6464 SUNSET BOULEVARD, BASEMENT, LOS ANGELES, CAL. COMP SOUTH







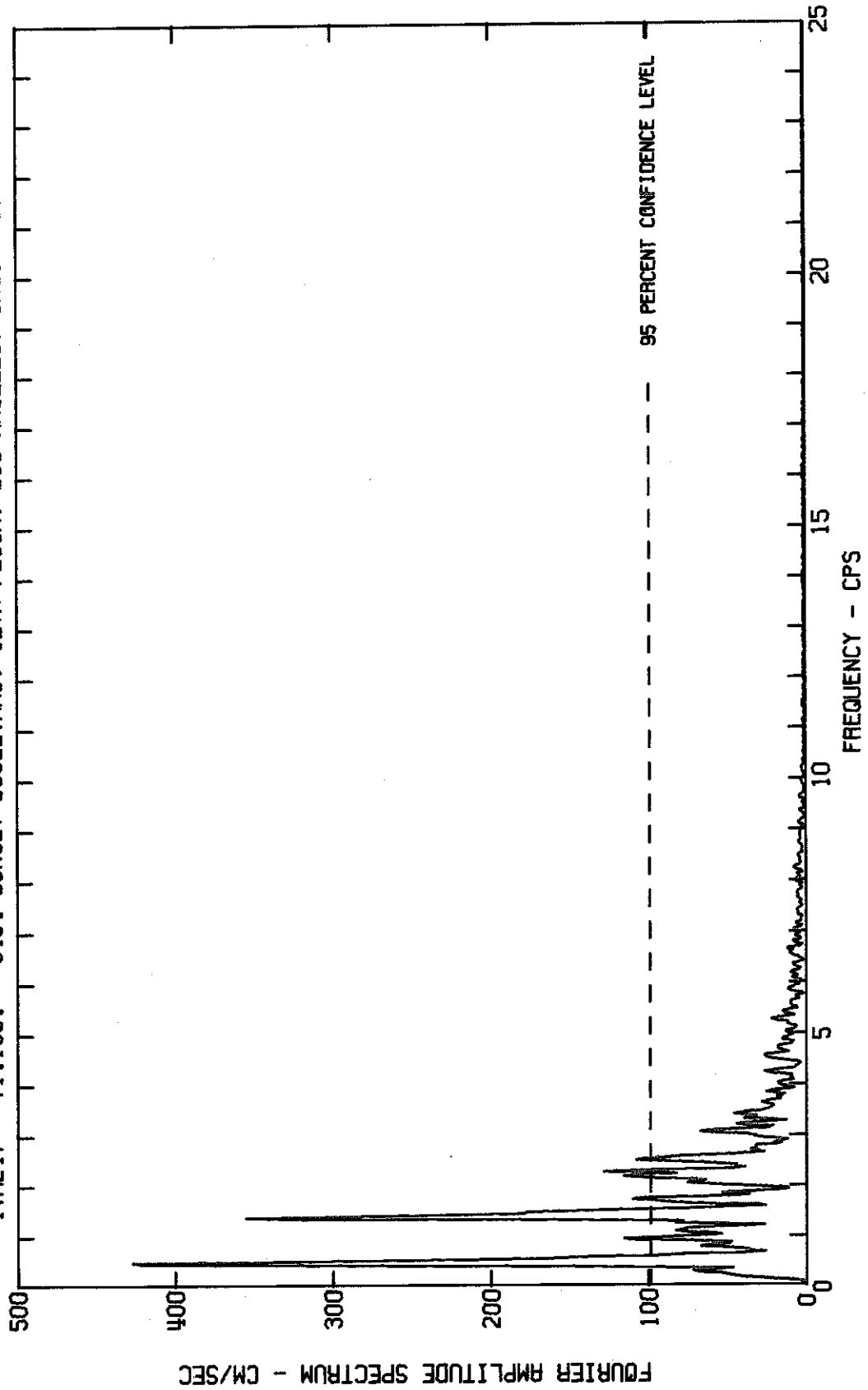


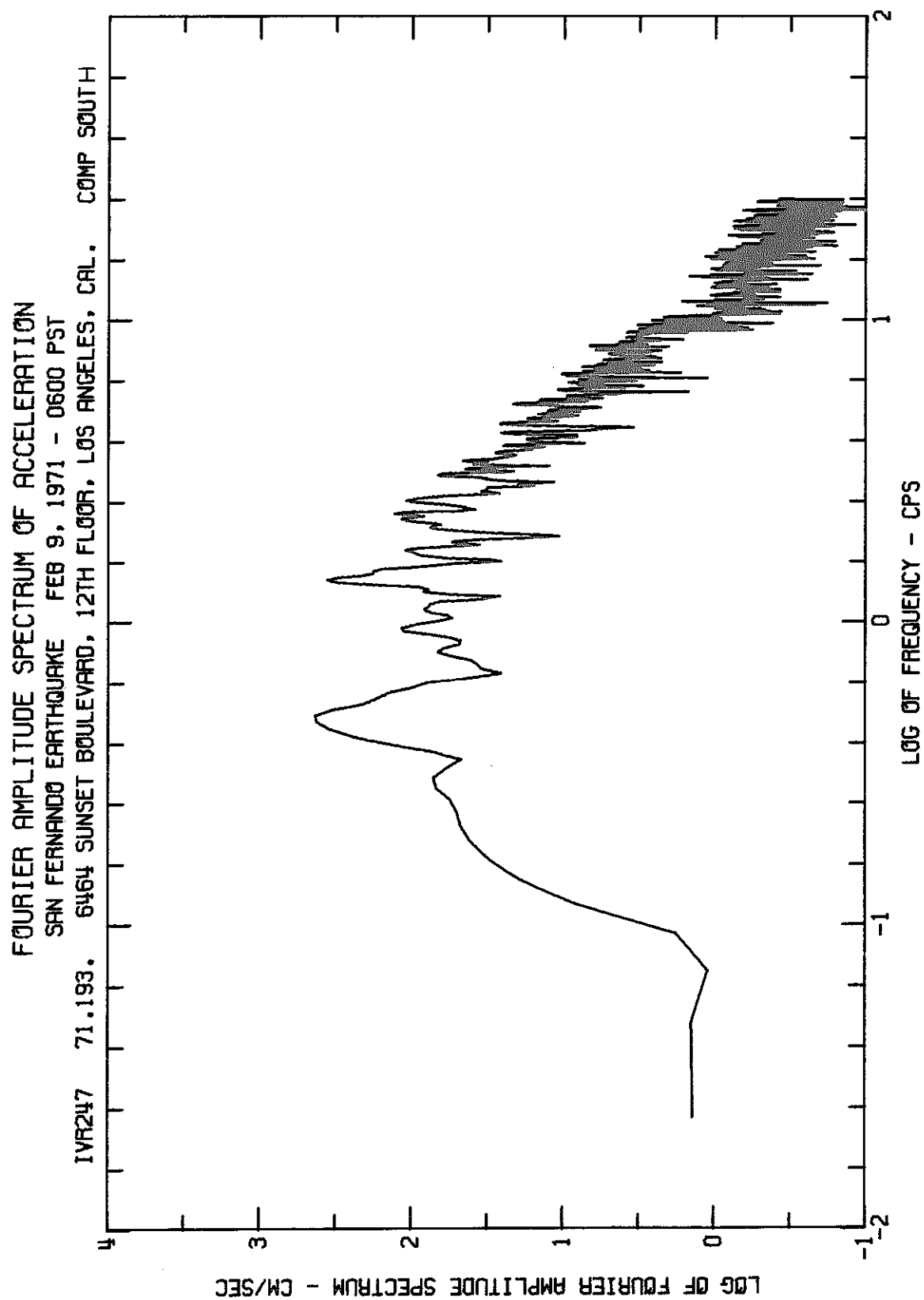


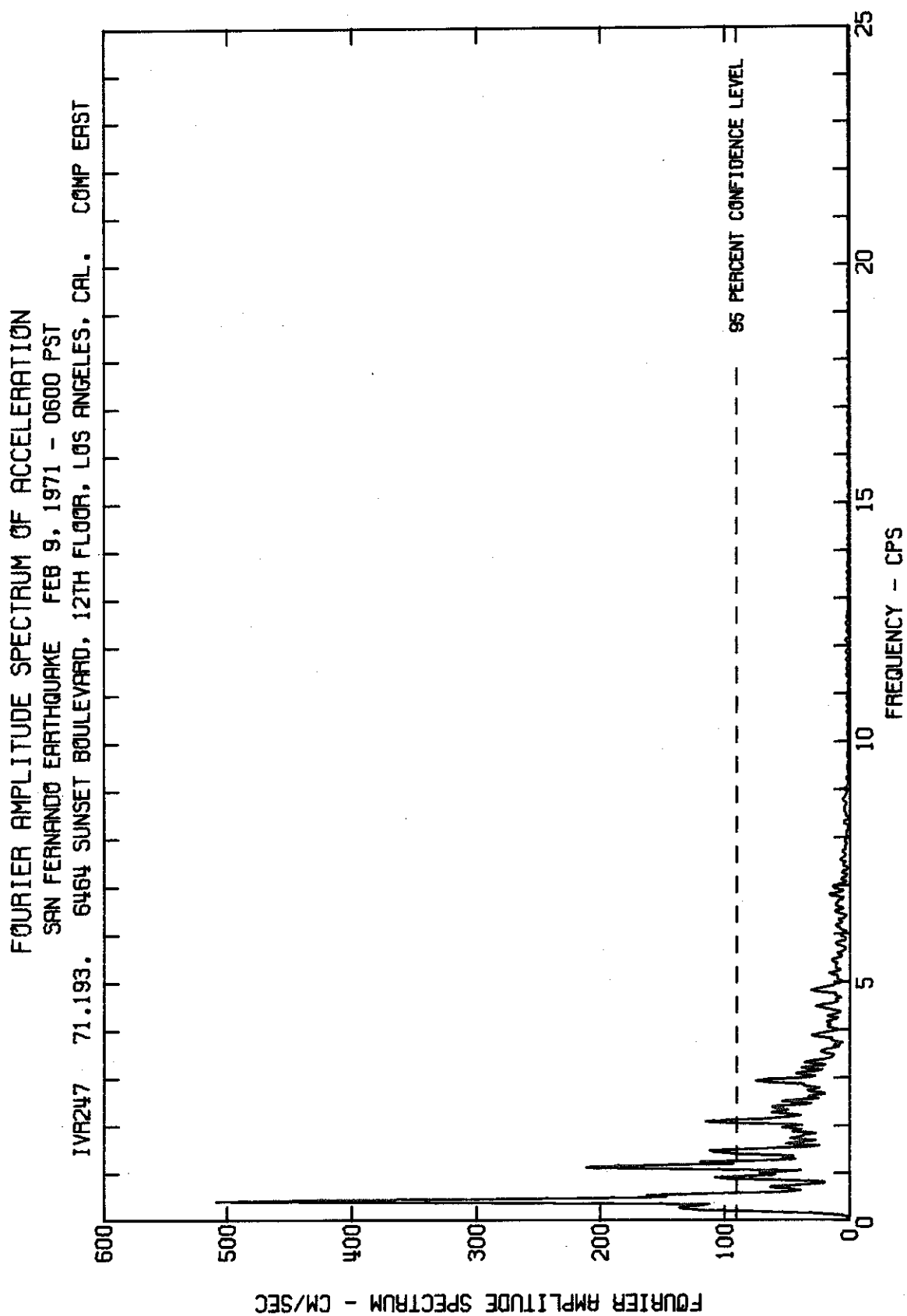
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

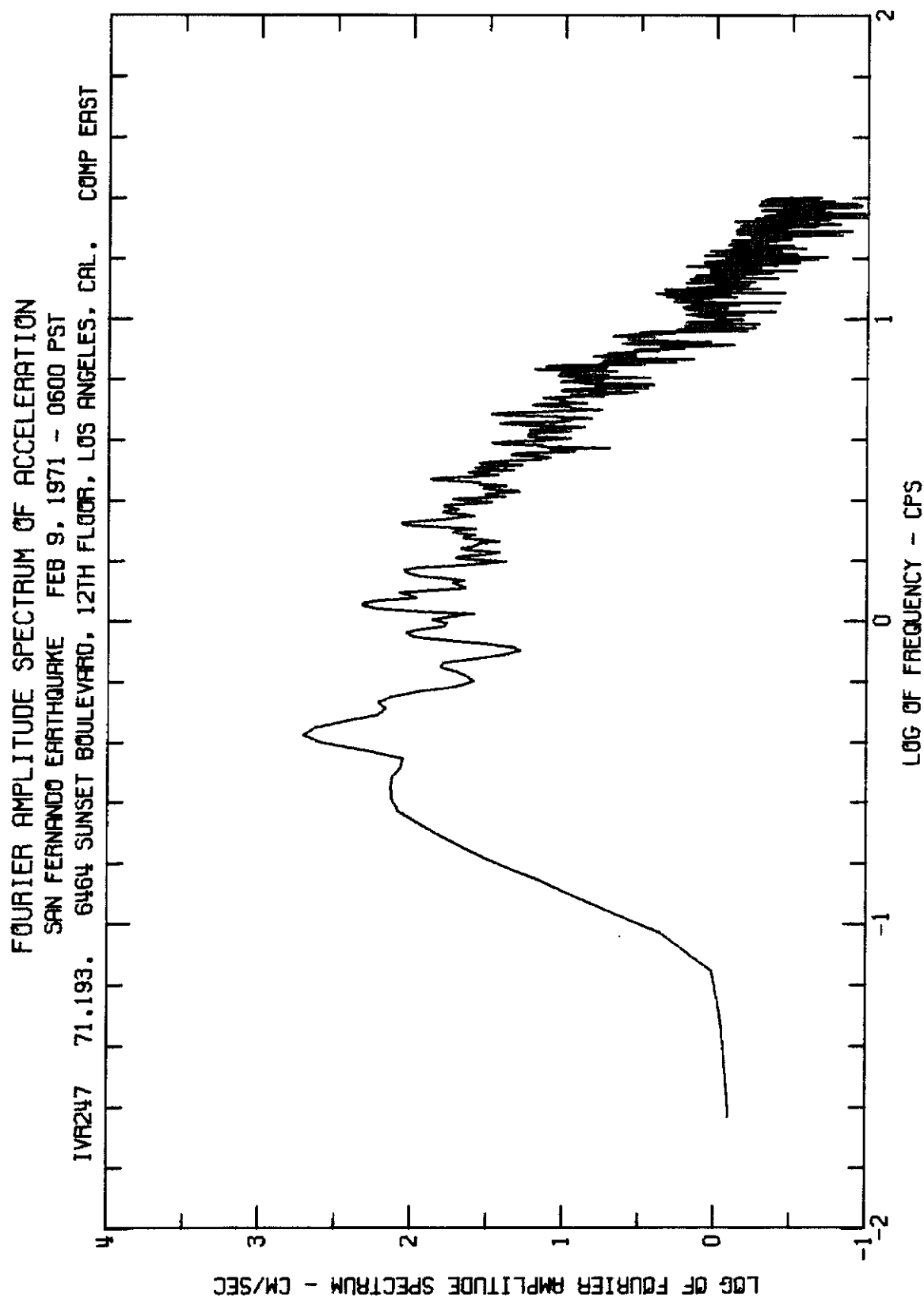
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

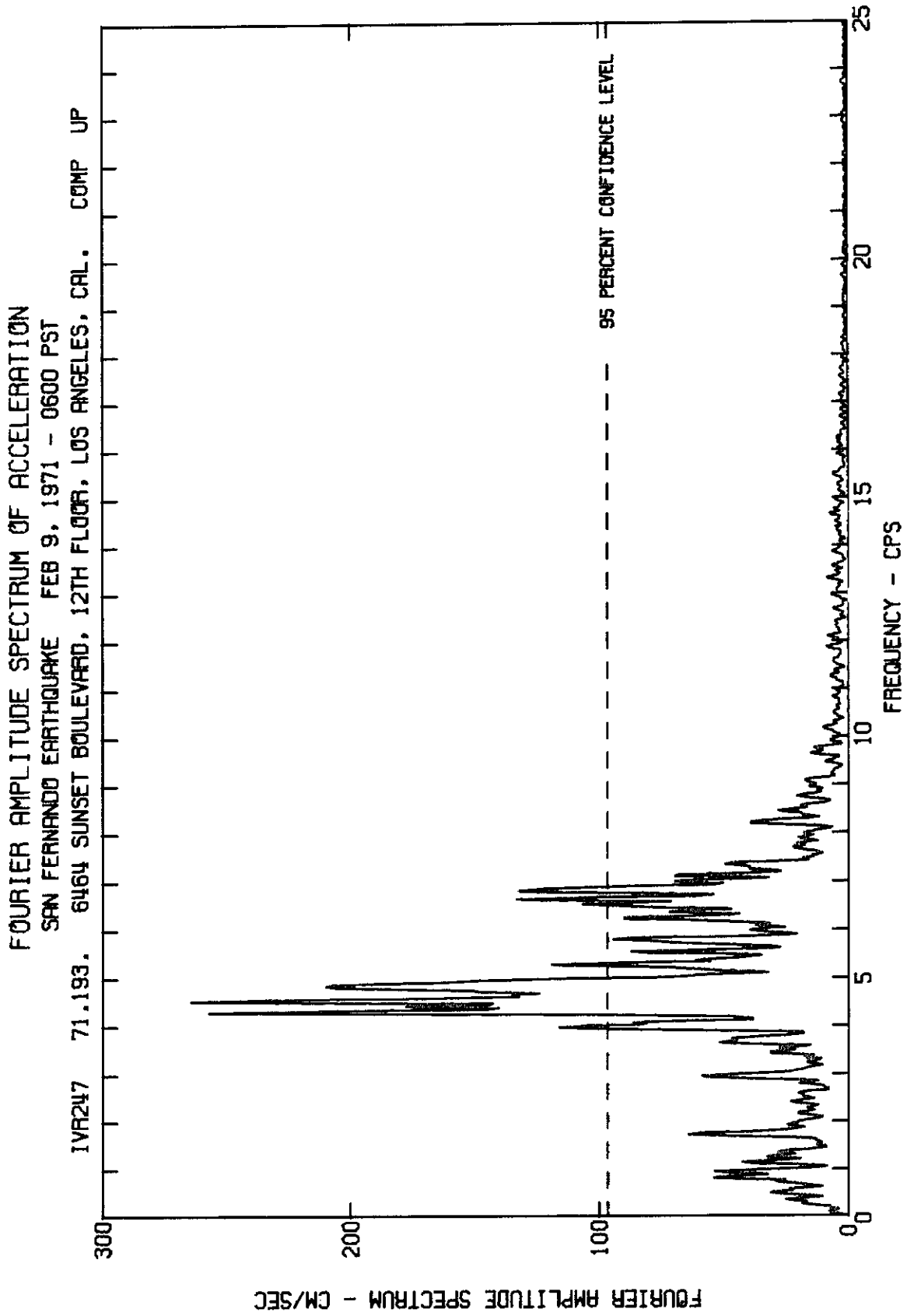
1VR247 71.193. 6464 SUNSET BOULEVARD, 12TH FLOOR, LOS ANGELES, CAL. COMP SOUTH

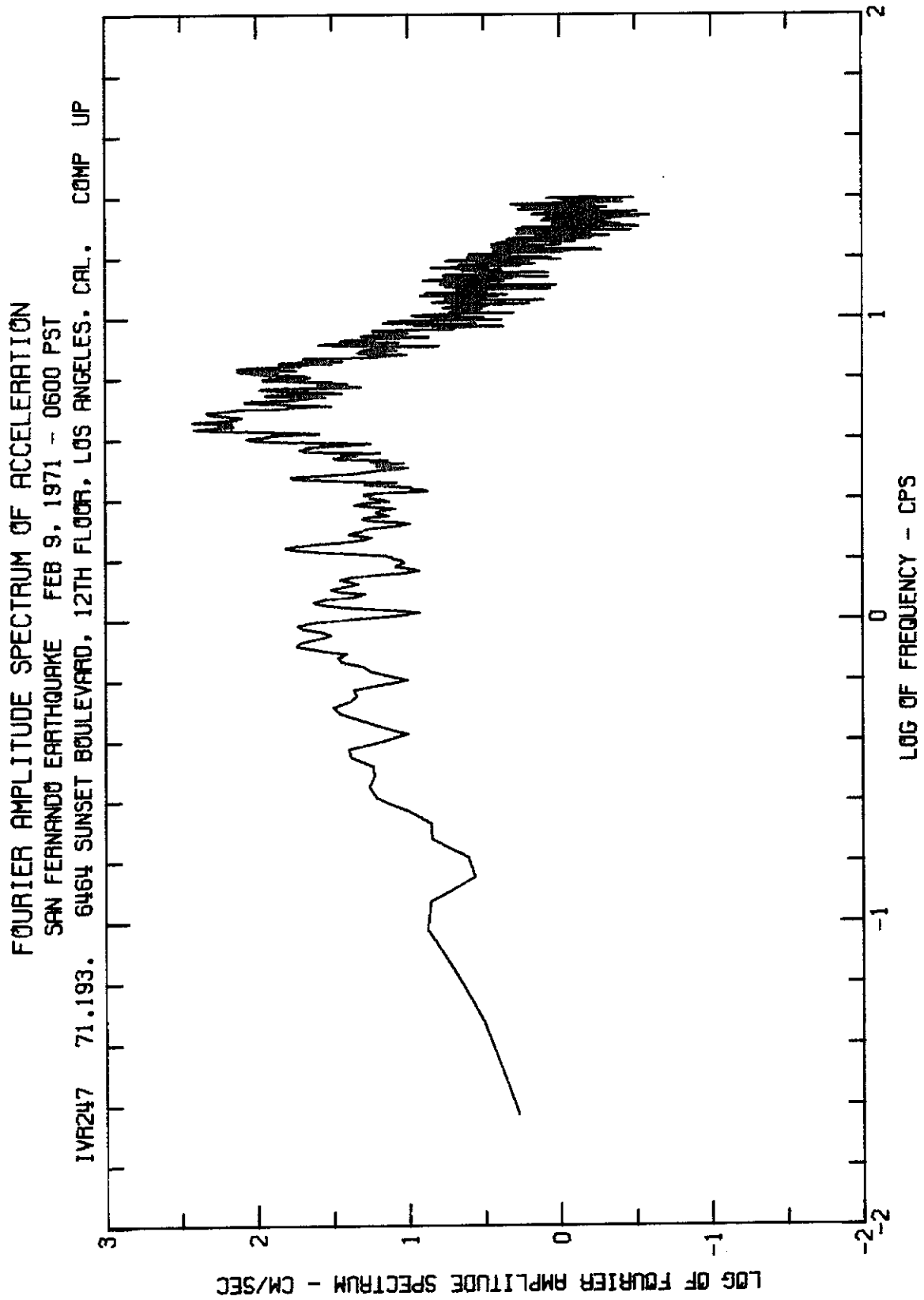


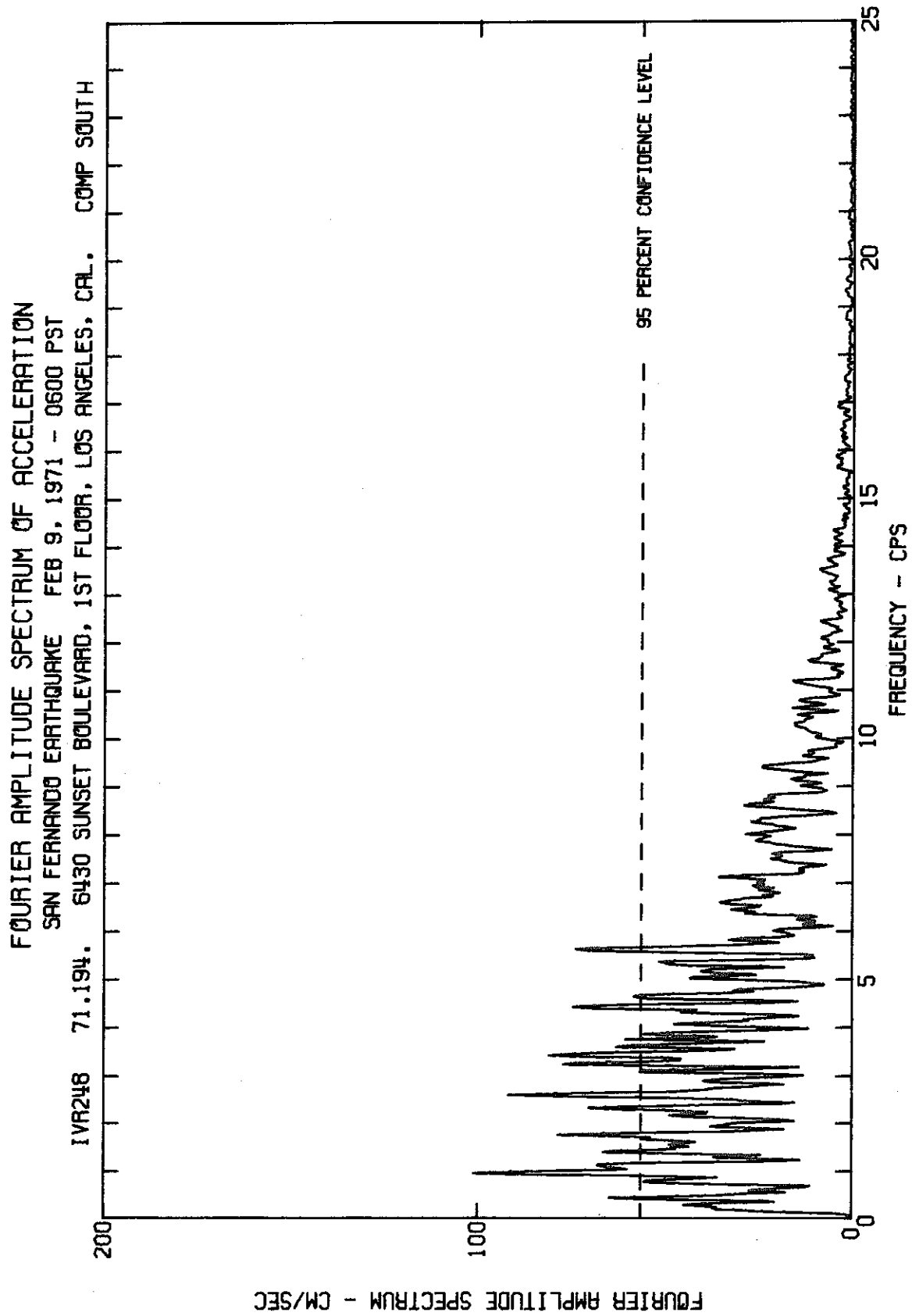








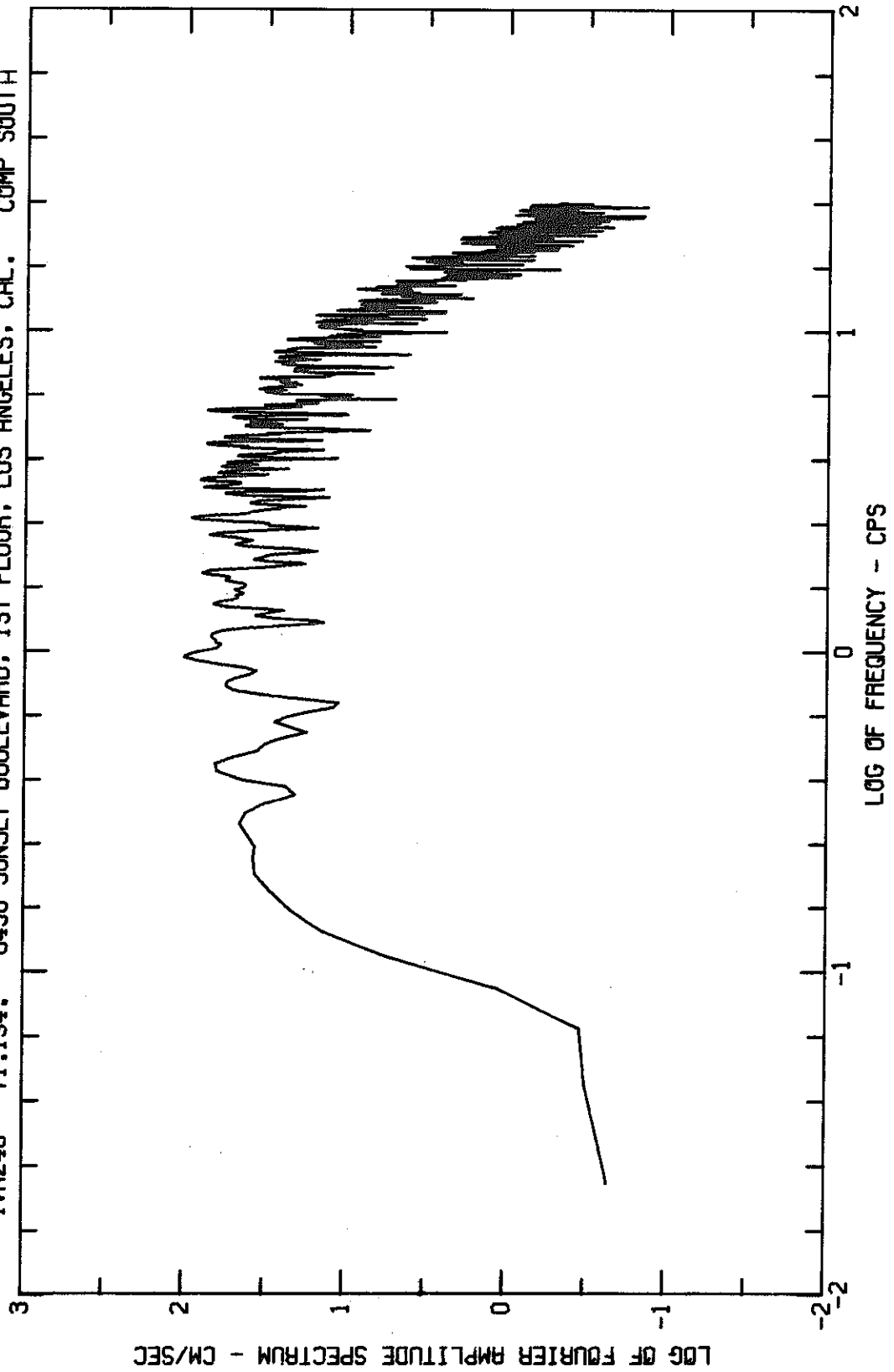




FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

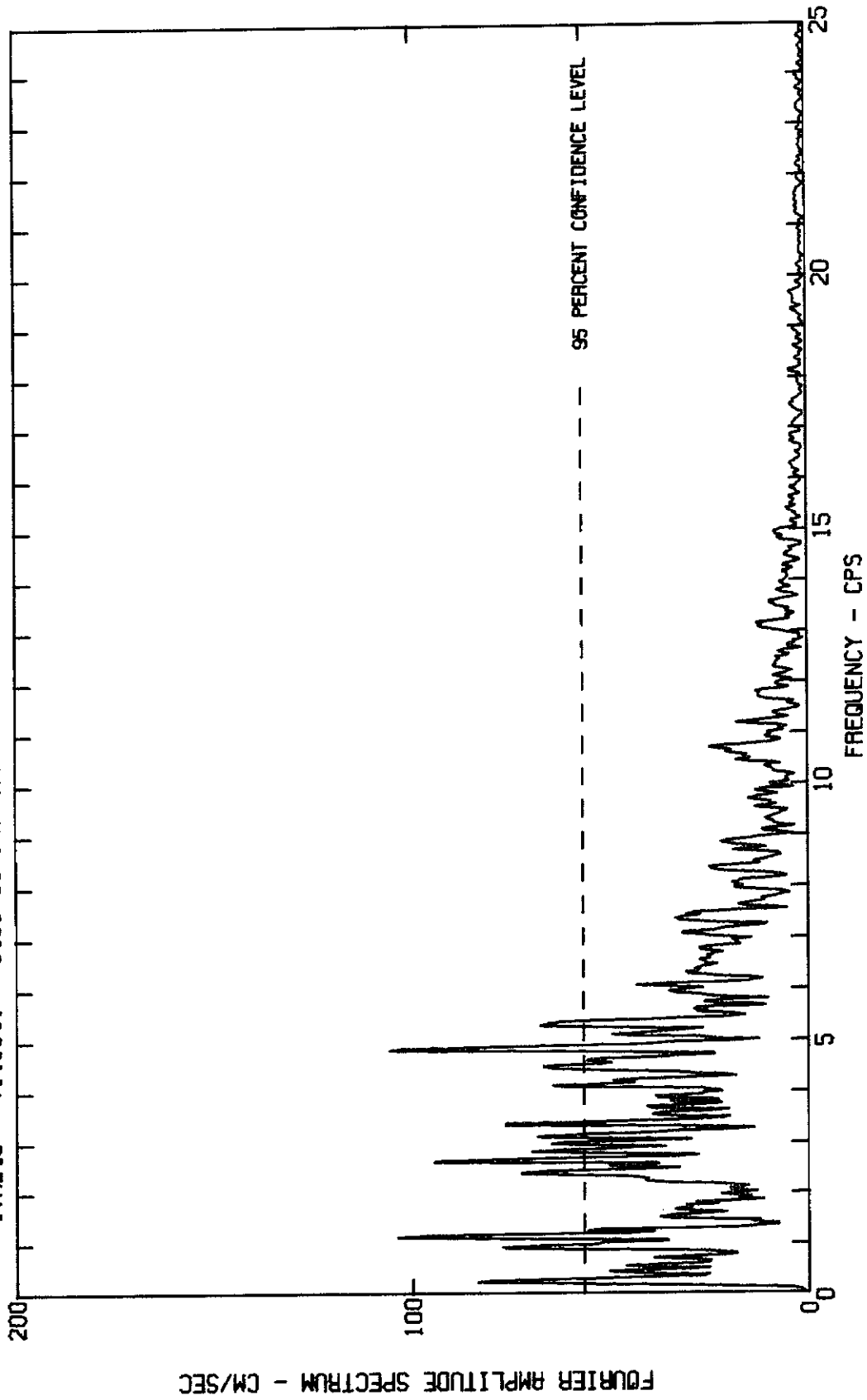
IVR248 71.194. 6430 SUNSET BOULEVARD, 1ST FLOOR, LOS ANGELES, CAL. COMP SOUTH

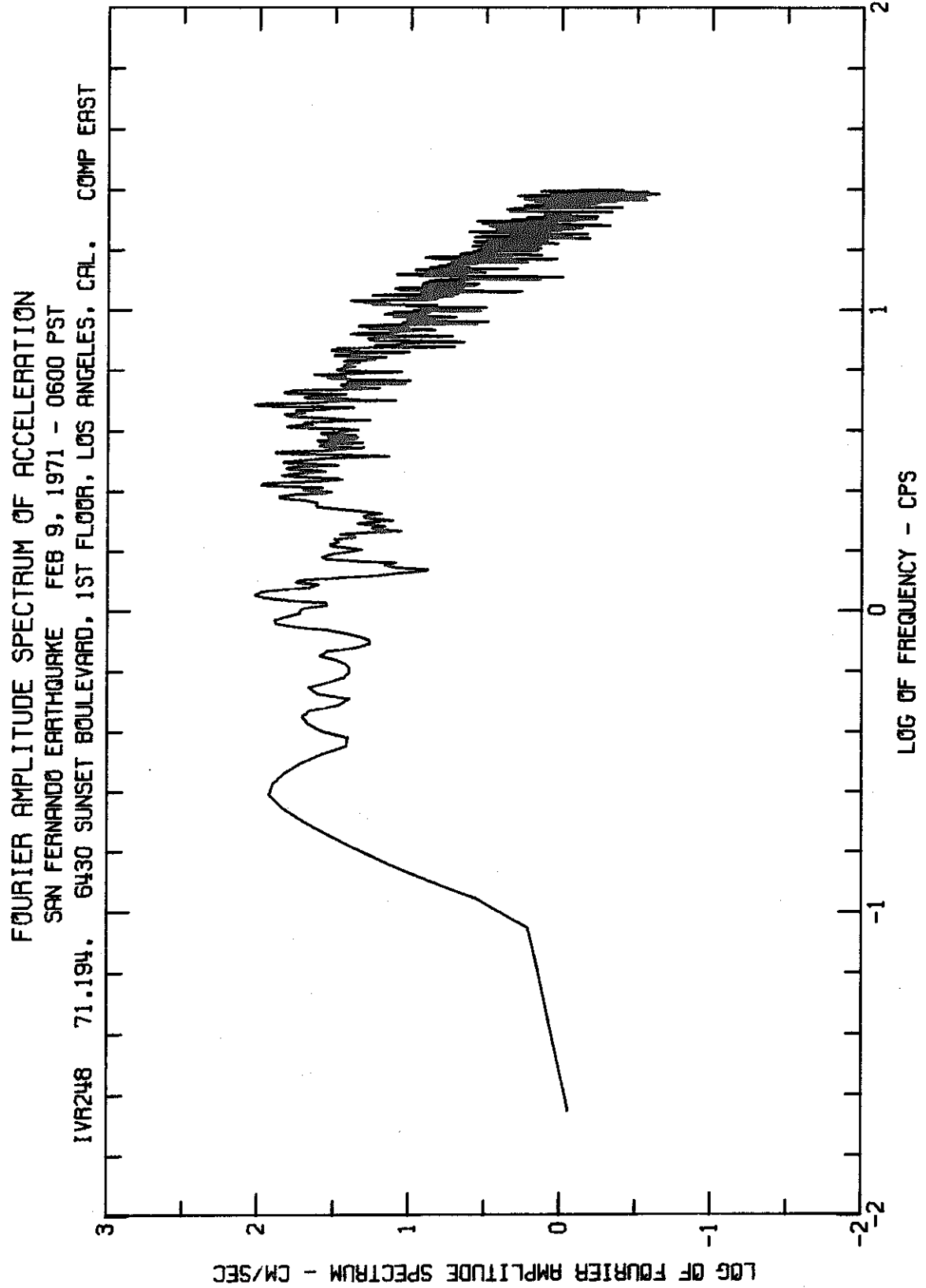


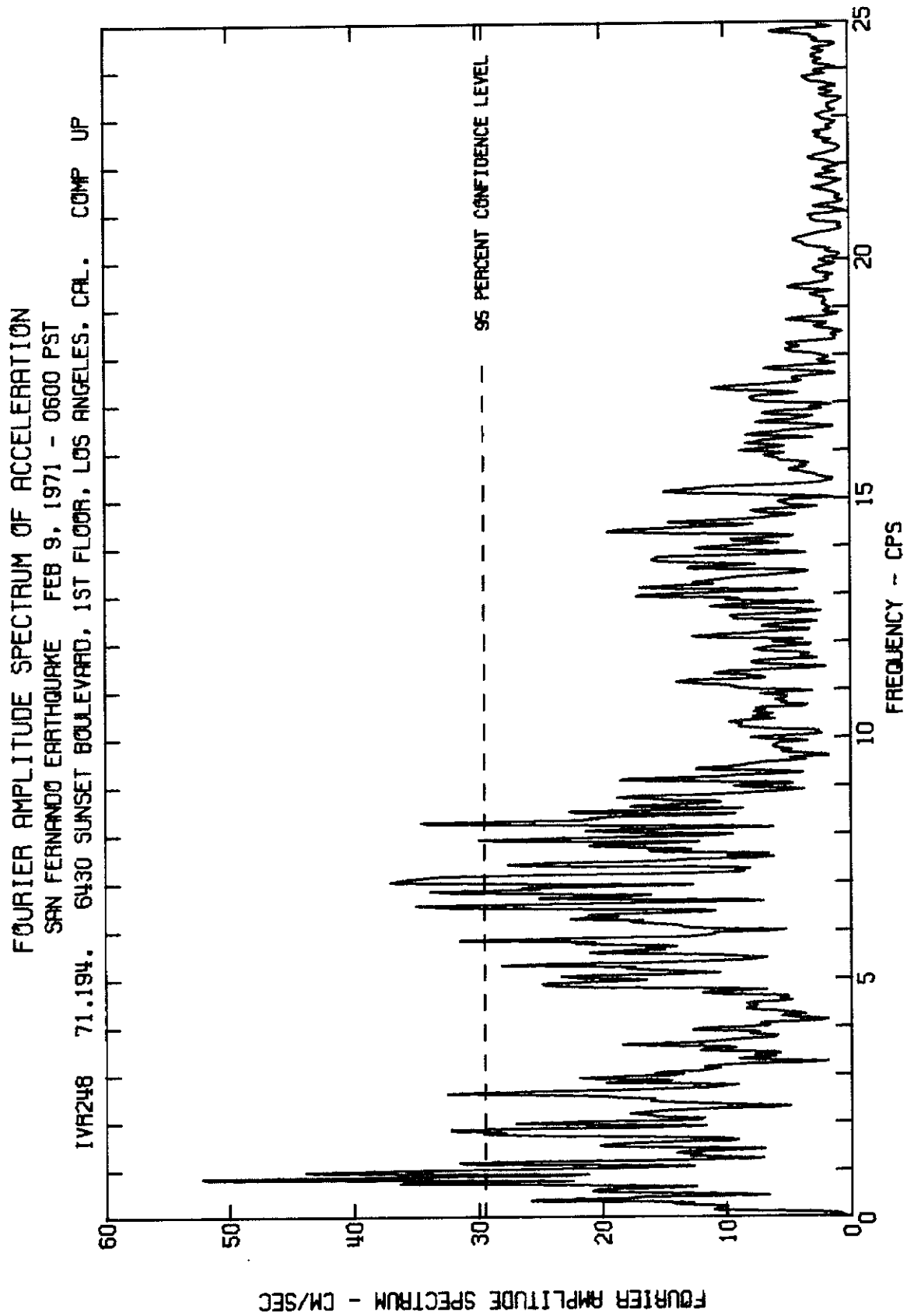
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

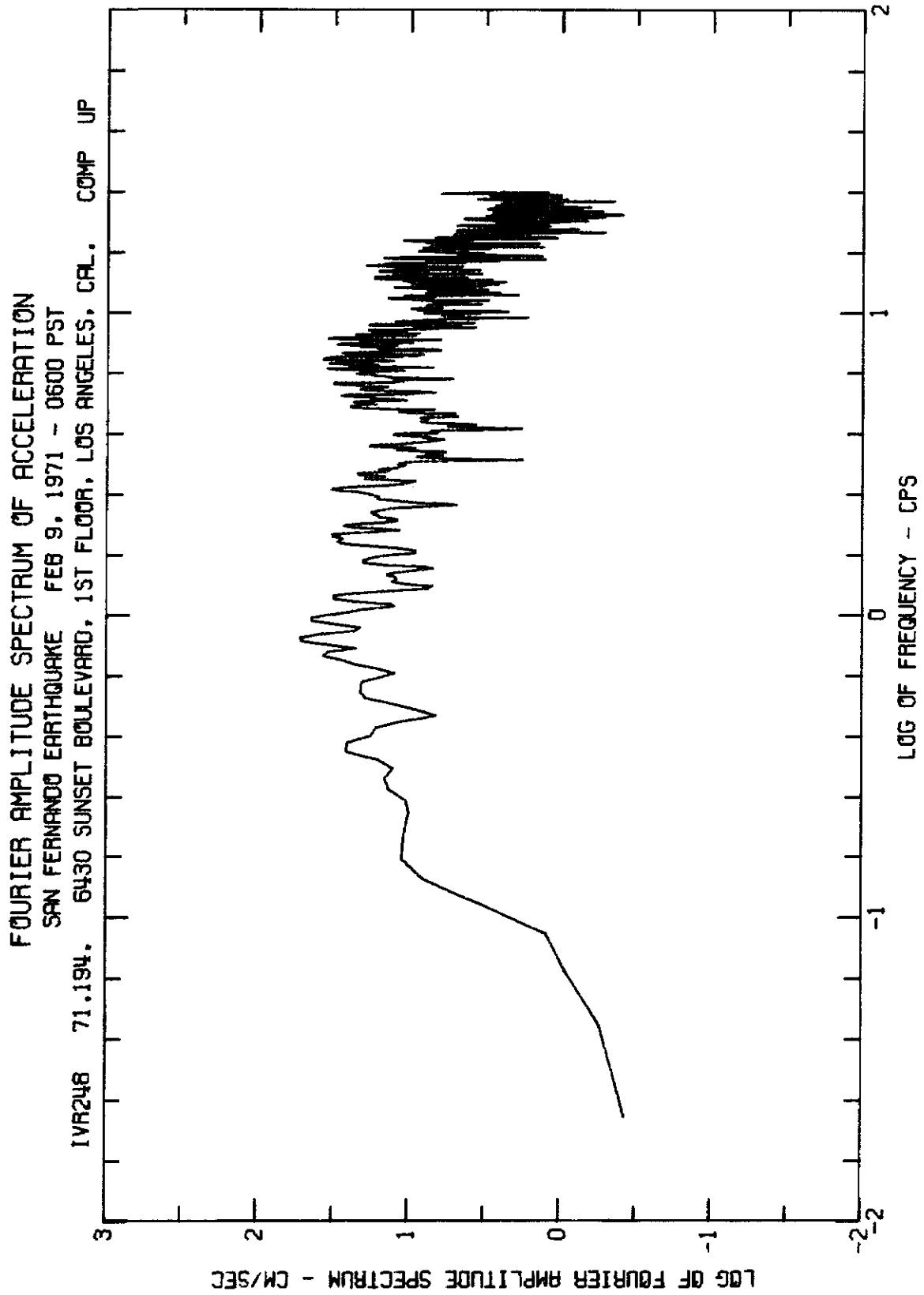
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

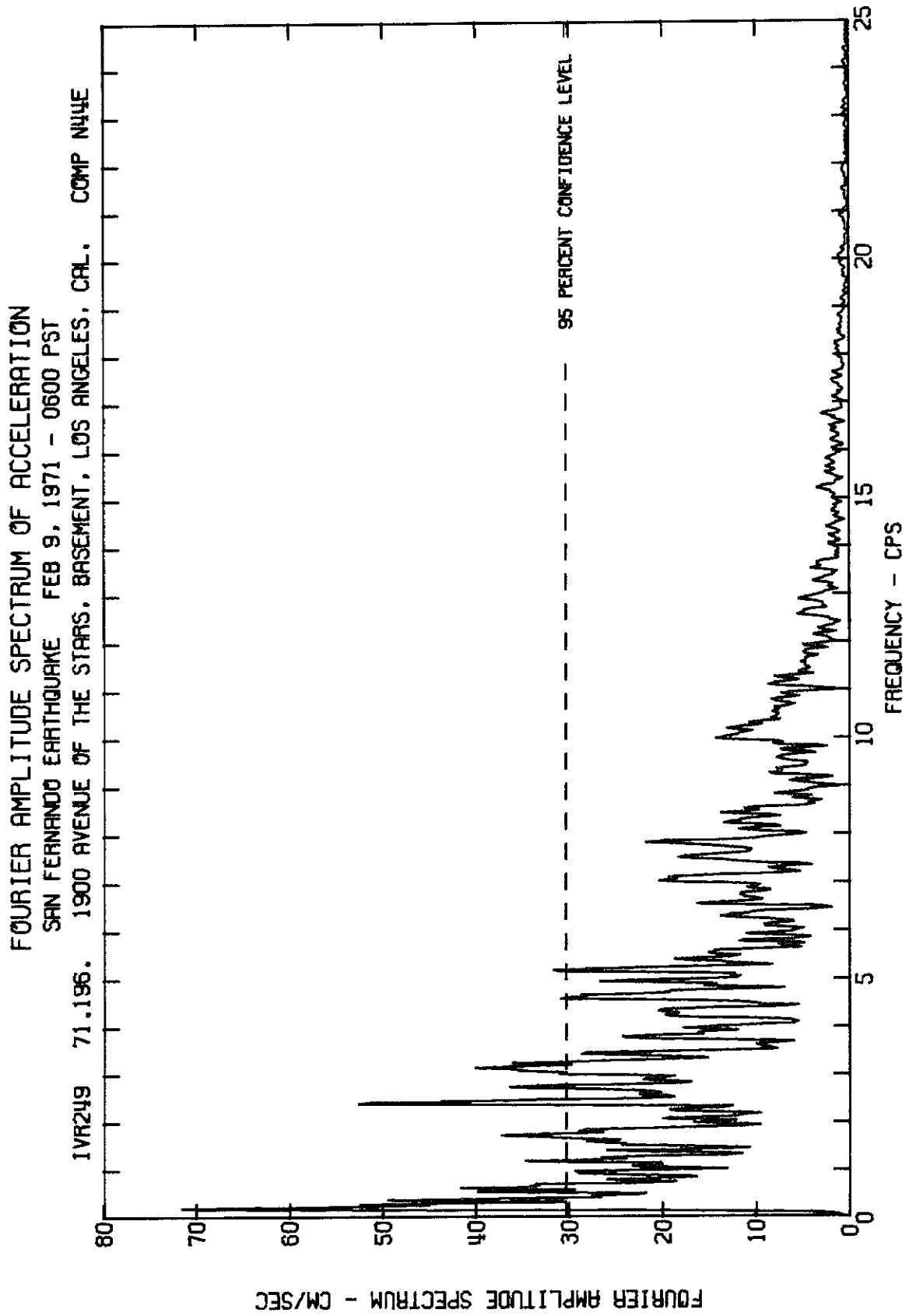
IVR248 71.134. 6430 SUNSET BOULEVARD, 1ST FLOOR, LOS ANGELES. CAL. COMP EAST

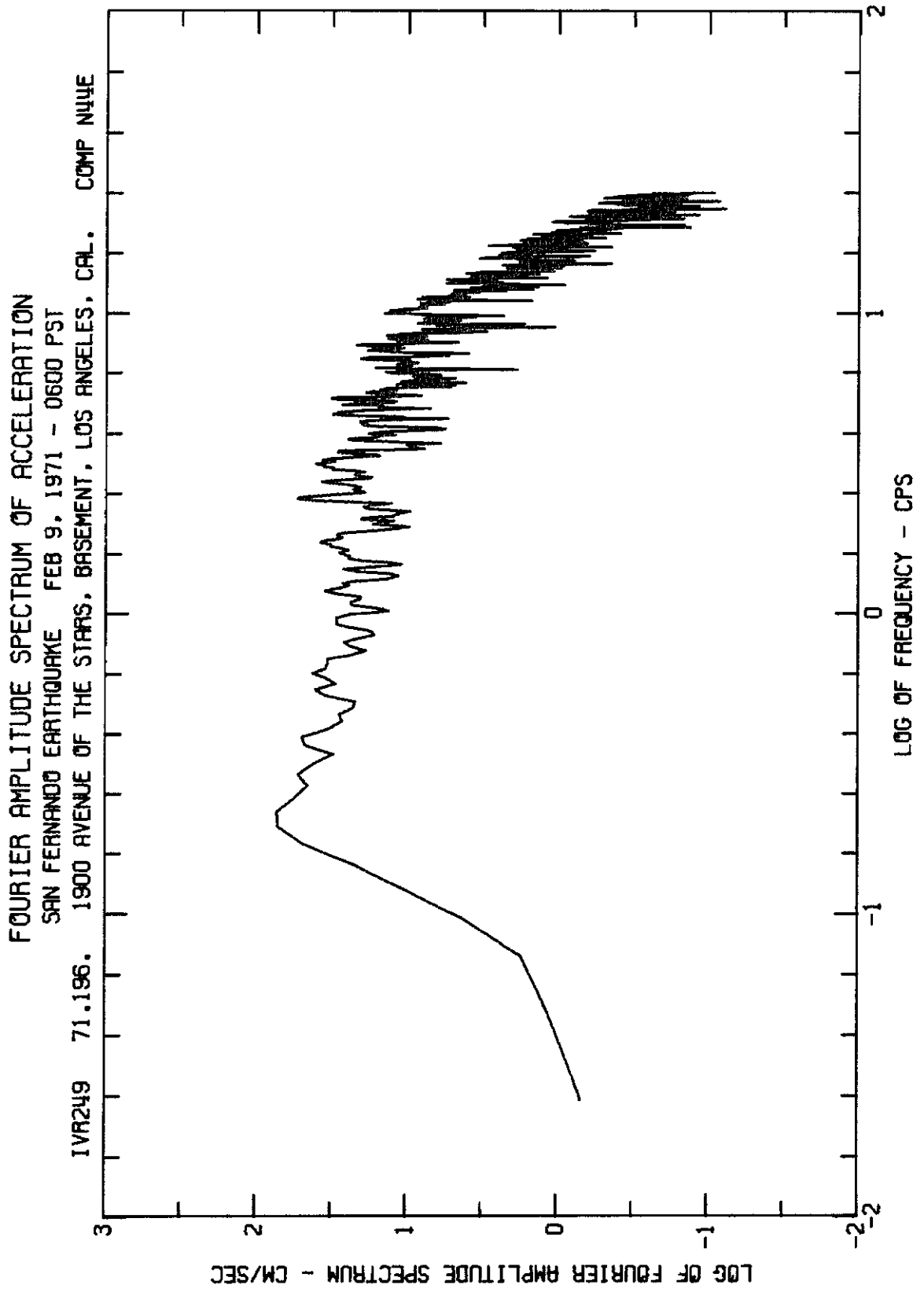


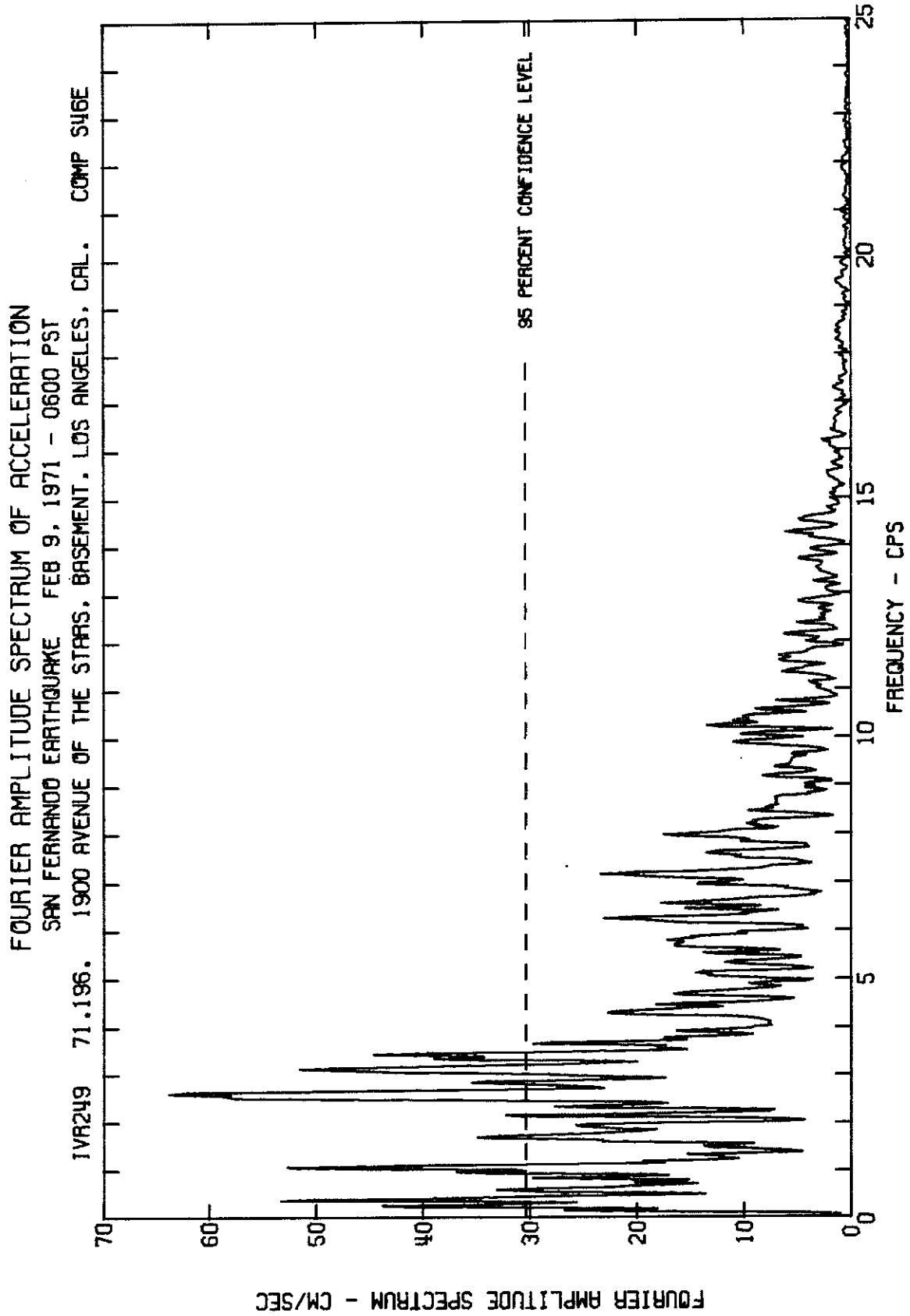


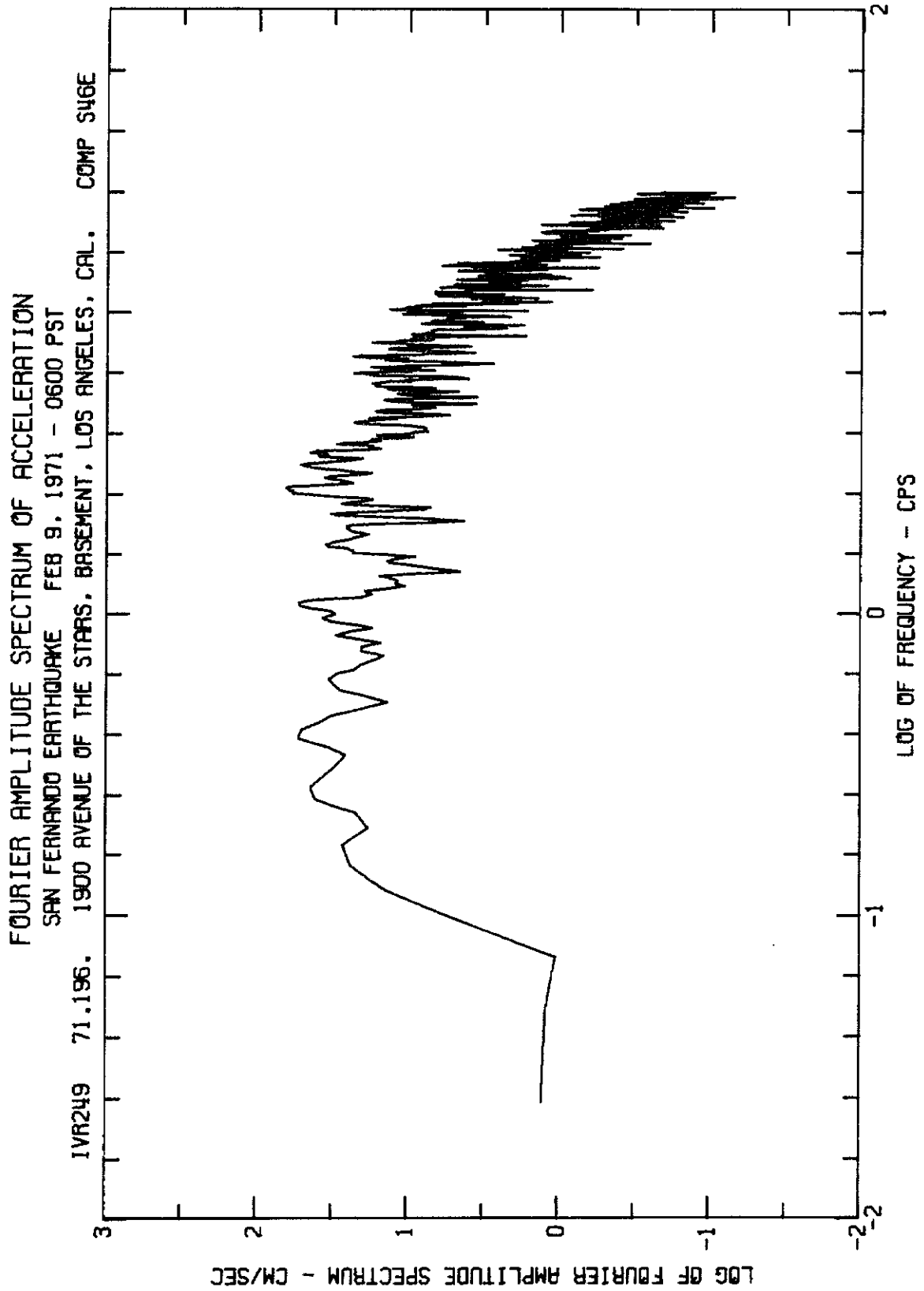








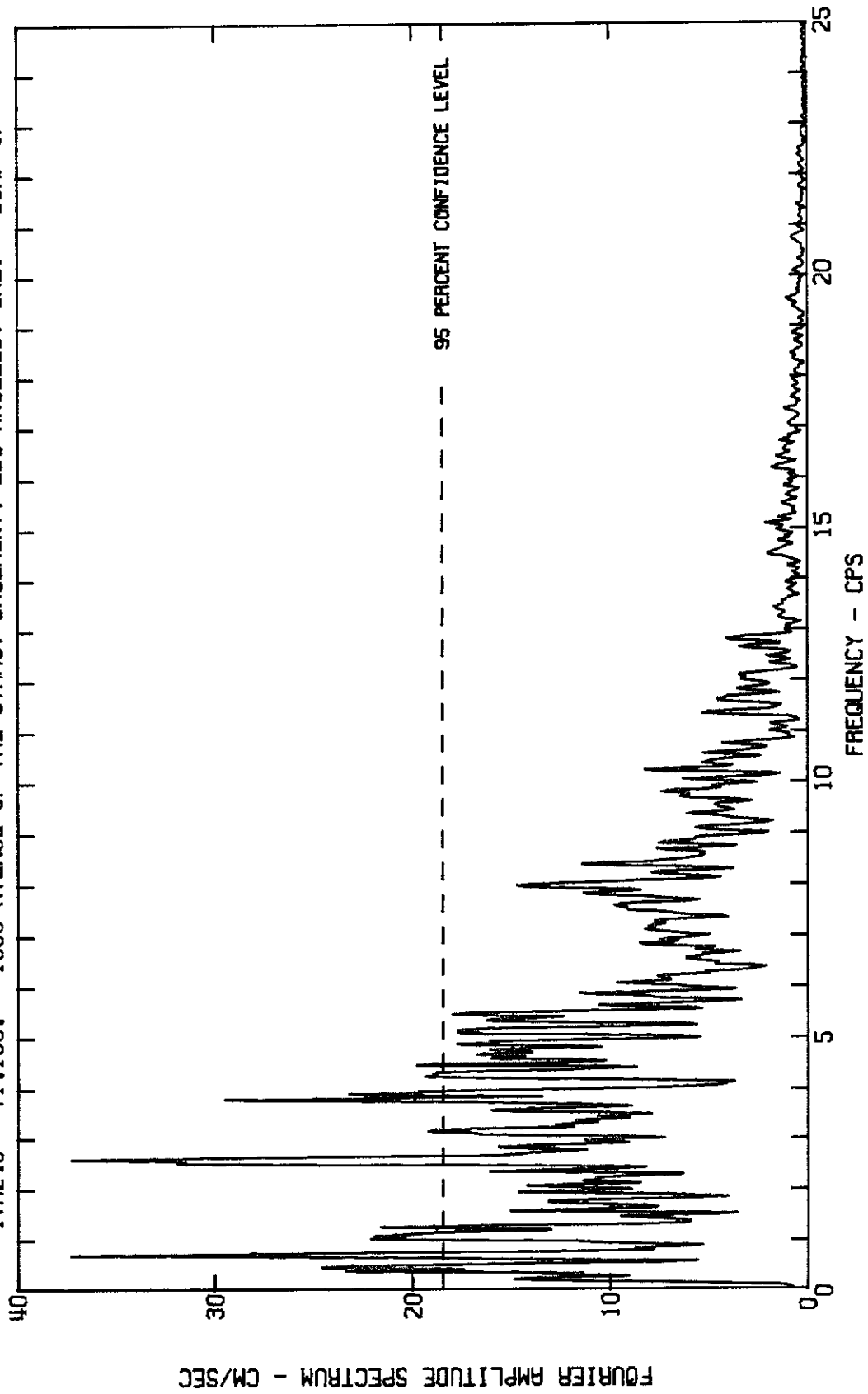


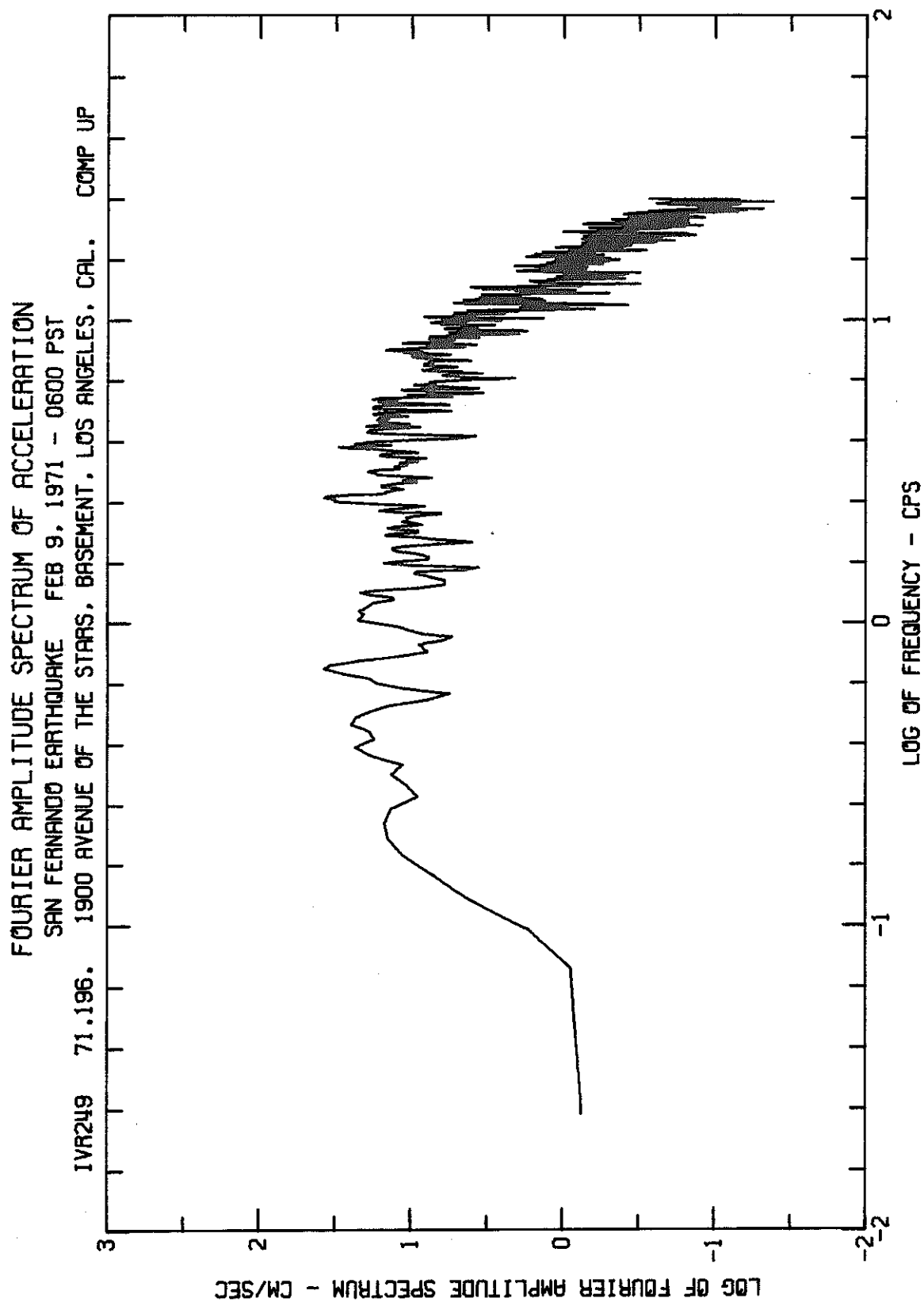


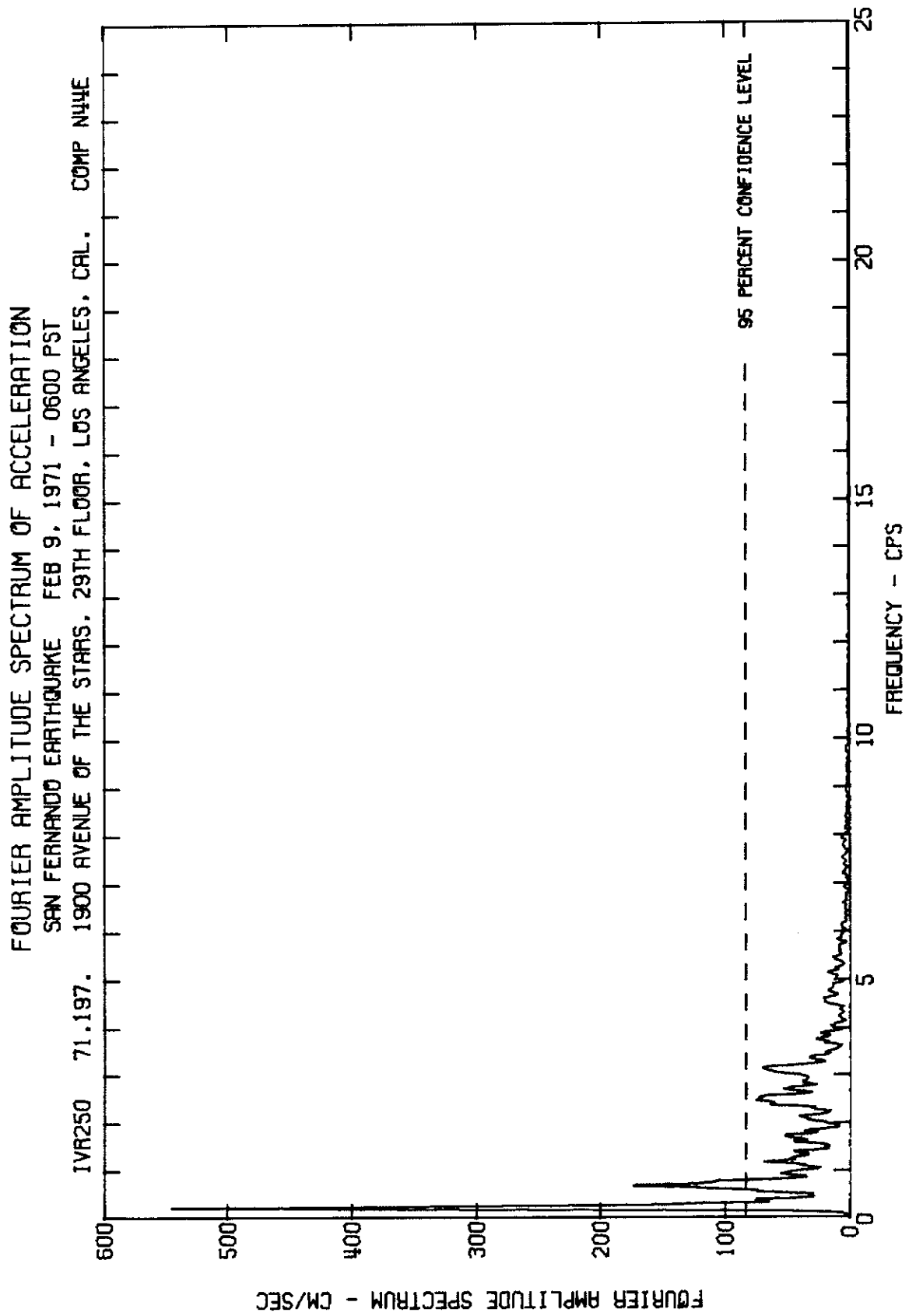
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

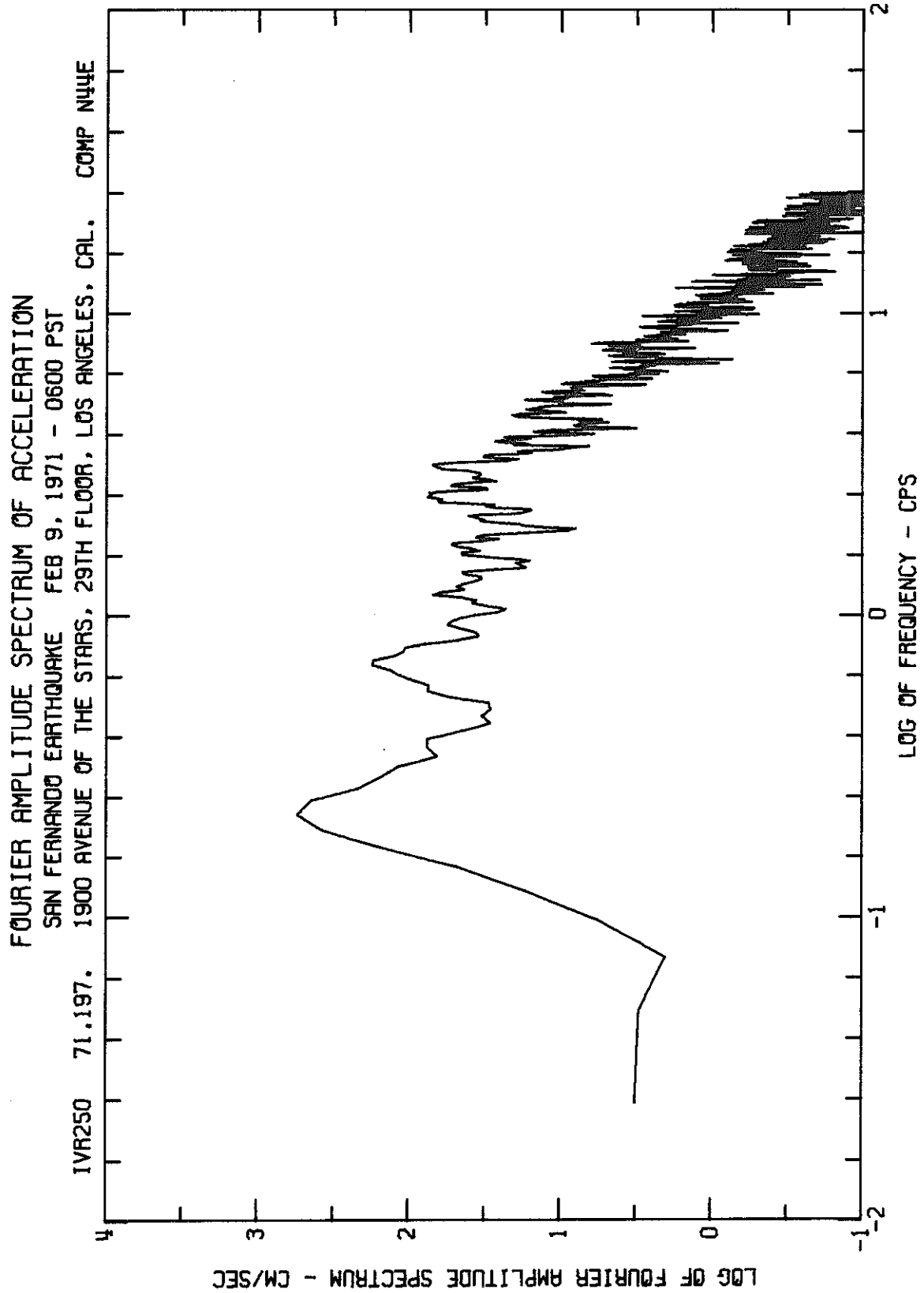
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

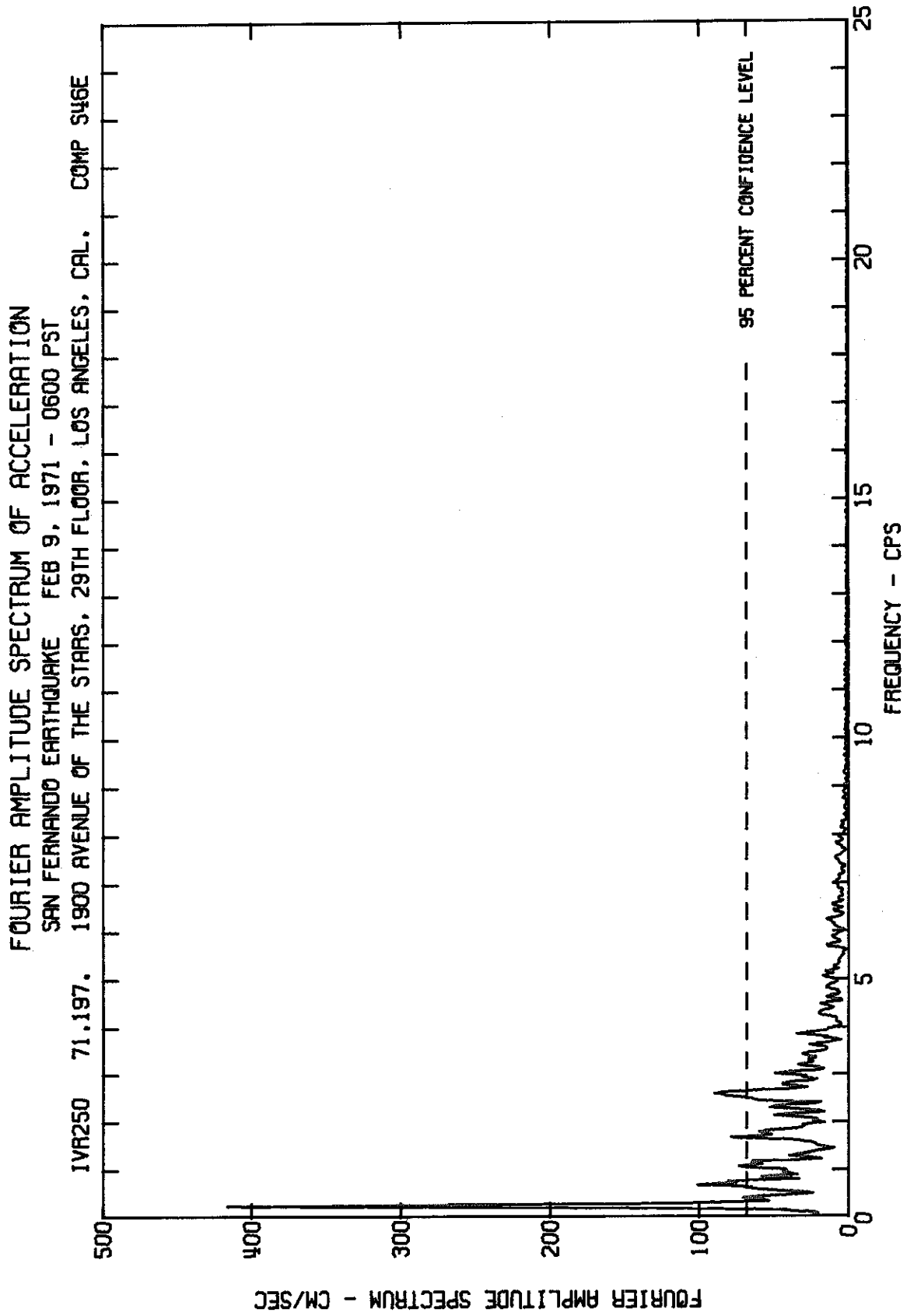
IVR249 71.196. 1900 AVENUE OF THE STARS, BASEMENT, LOS ANGELES, CAL. COMP UP

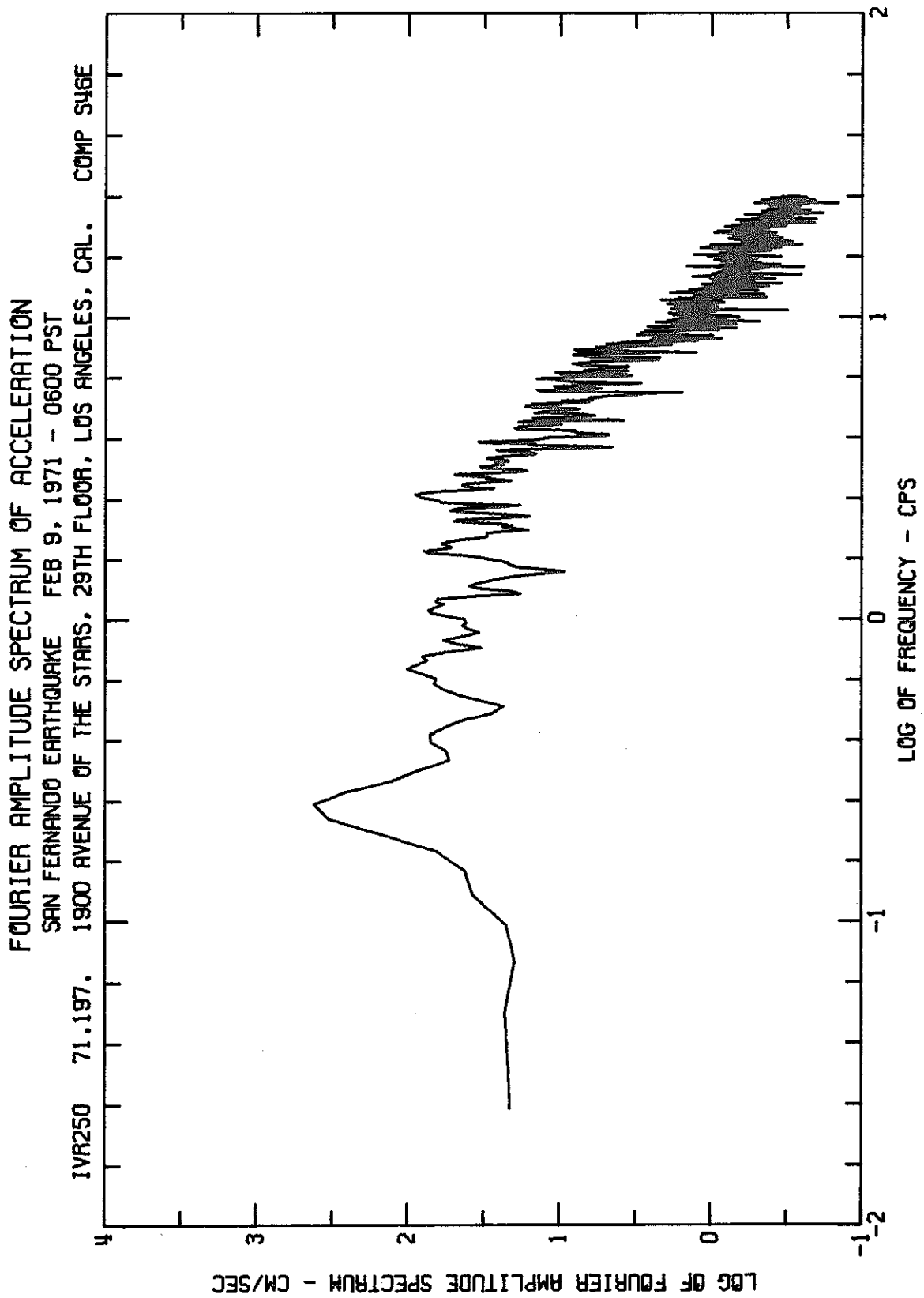


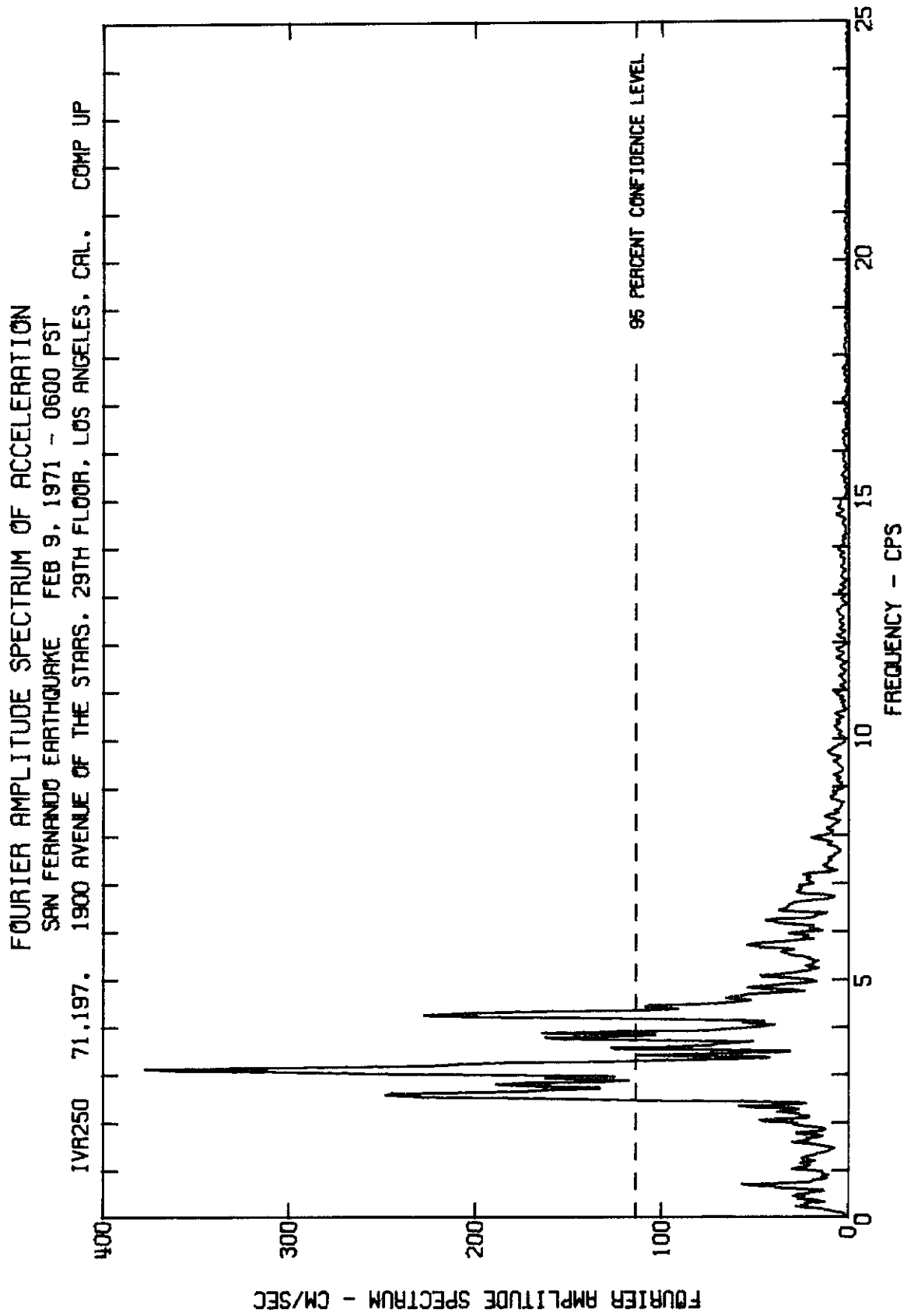


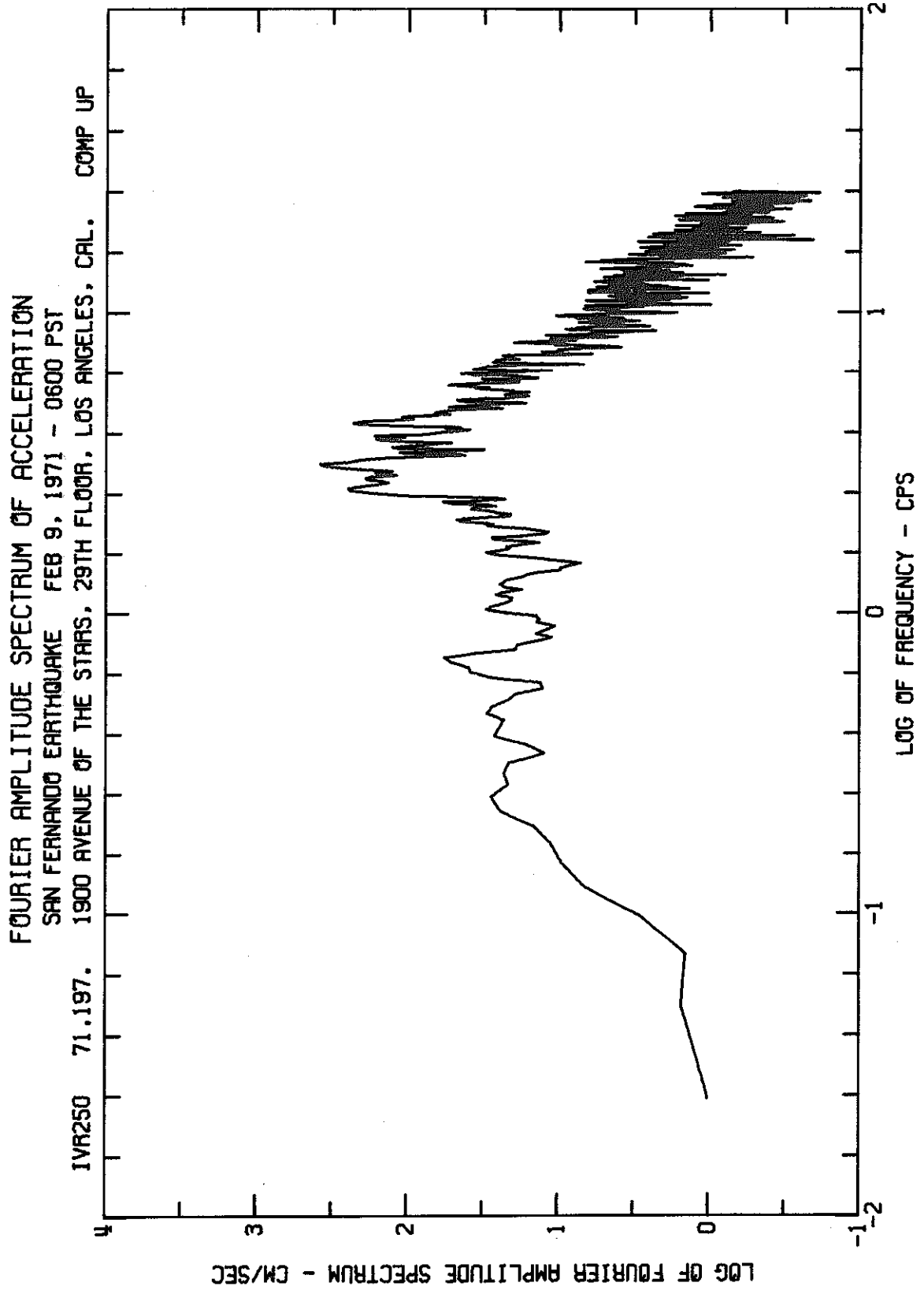


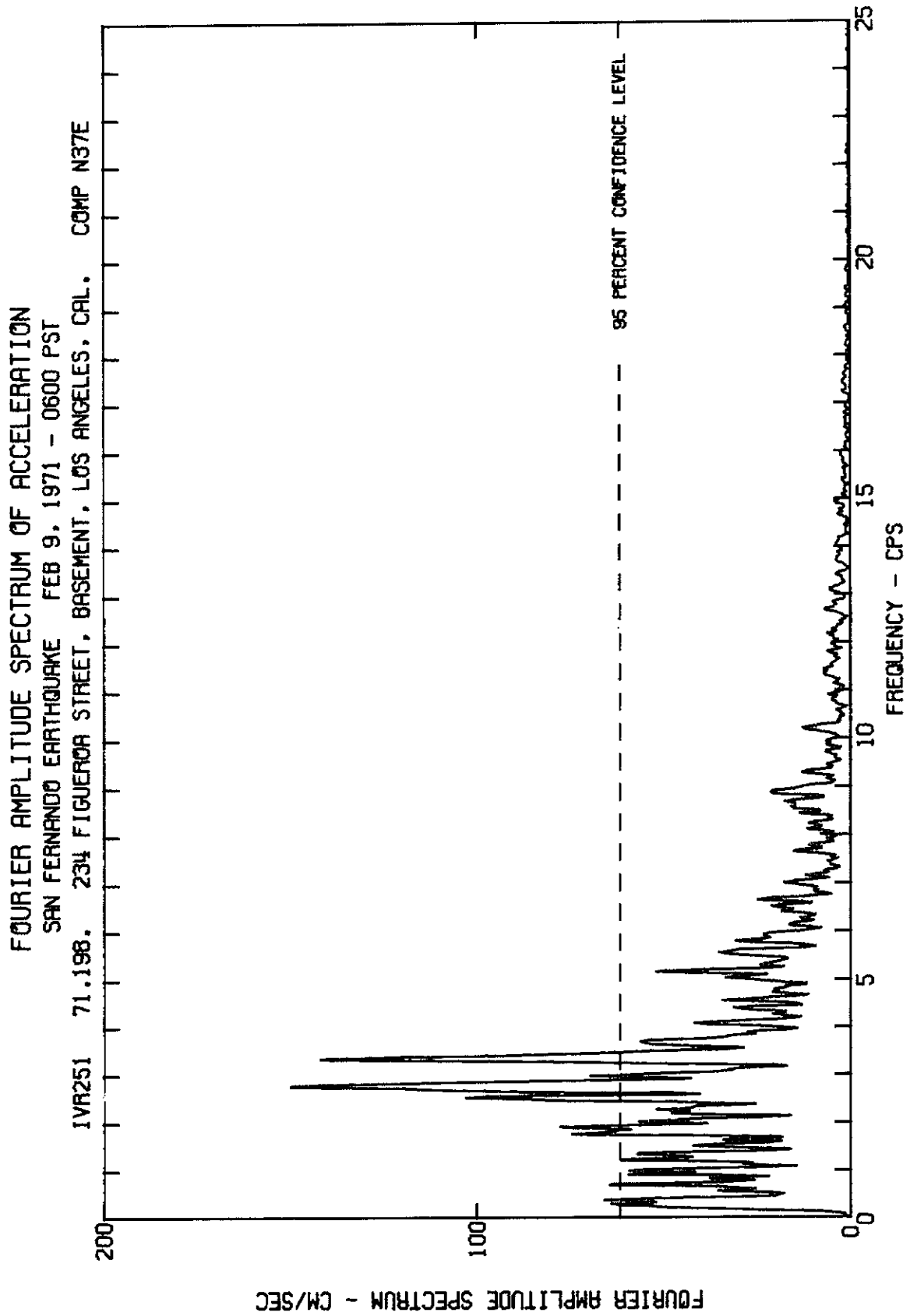


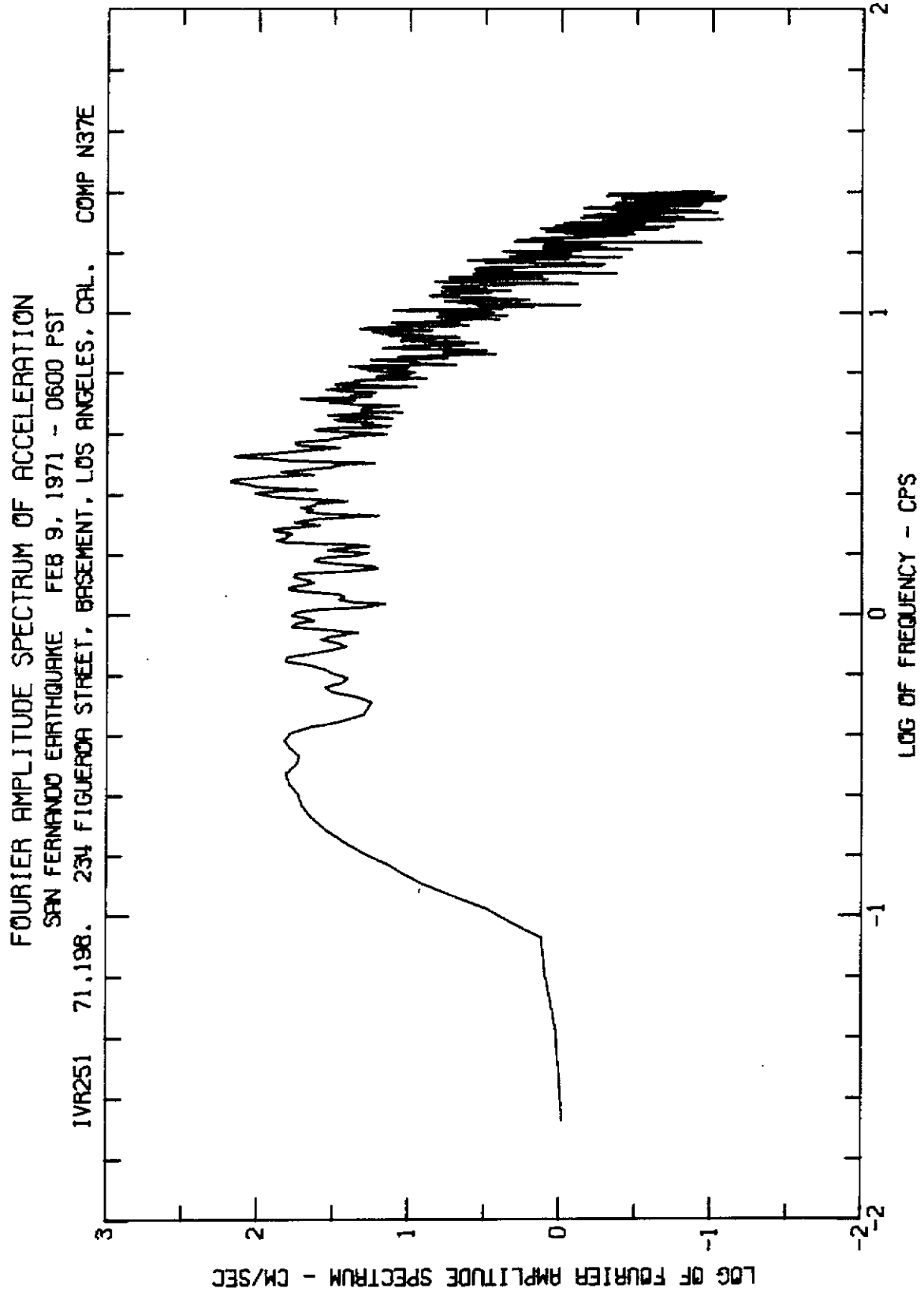


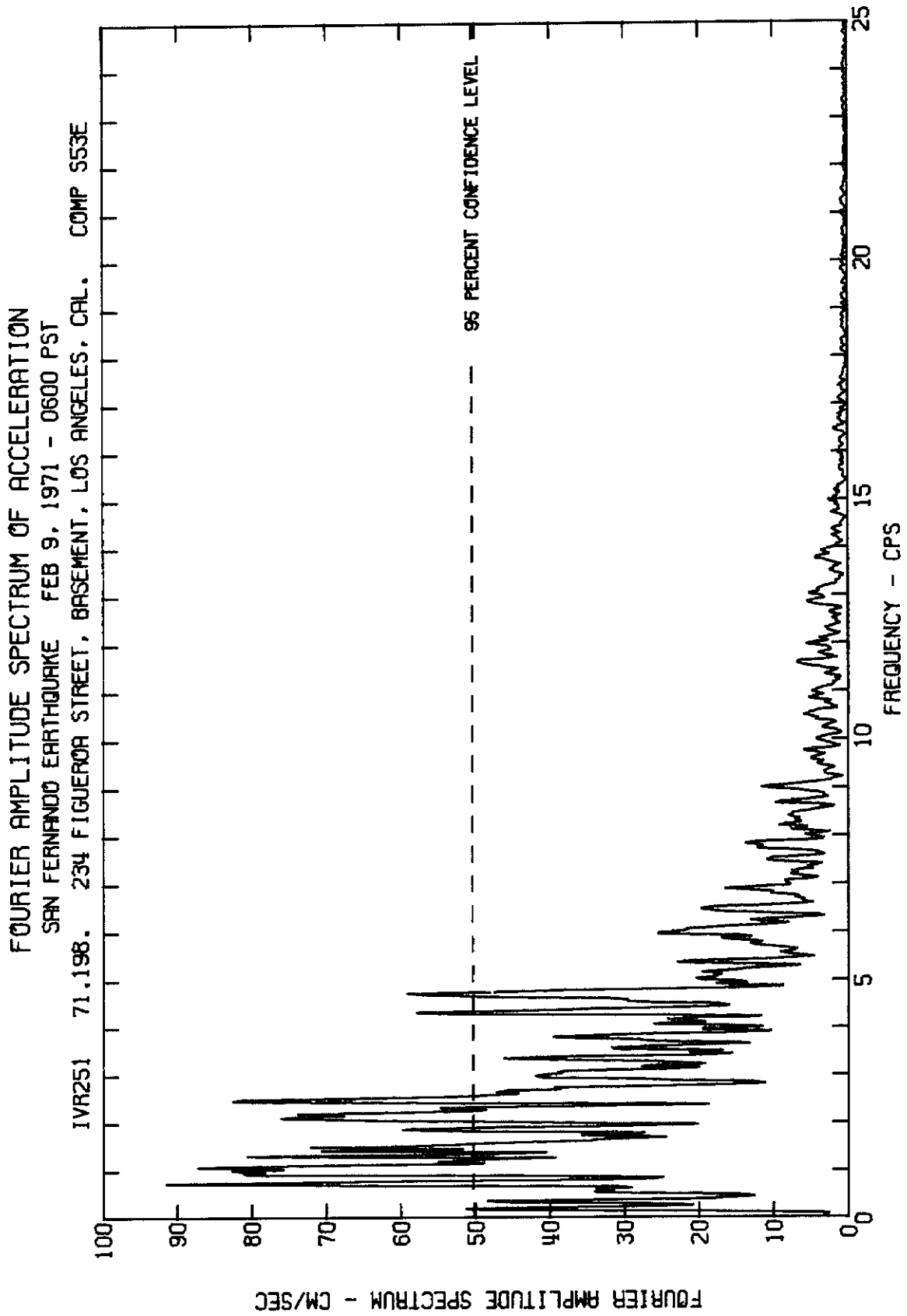


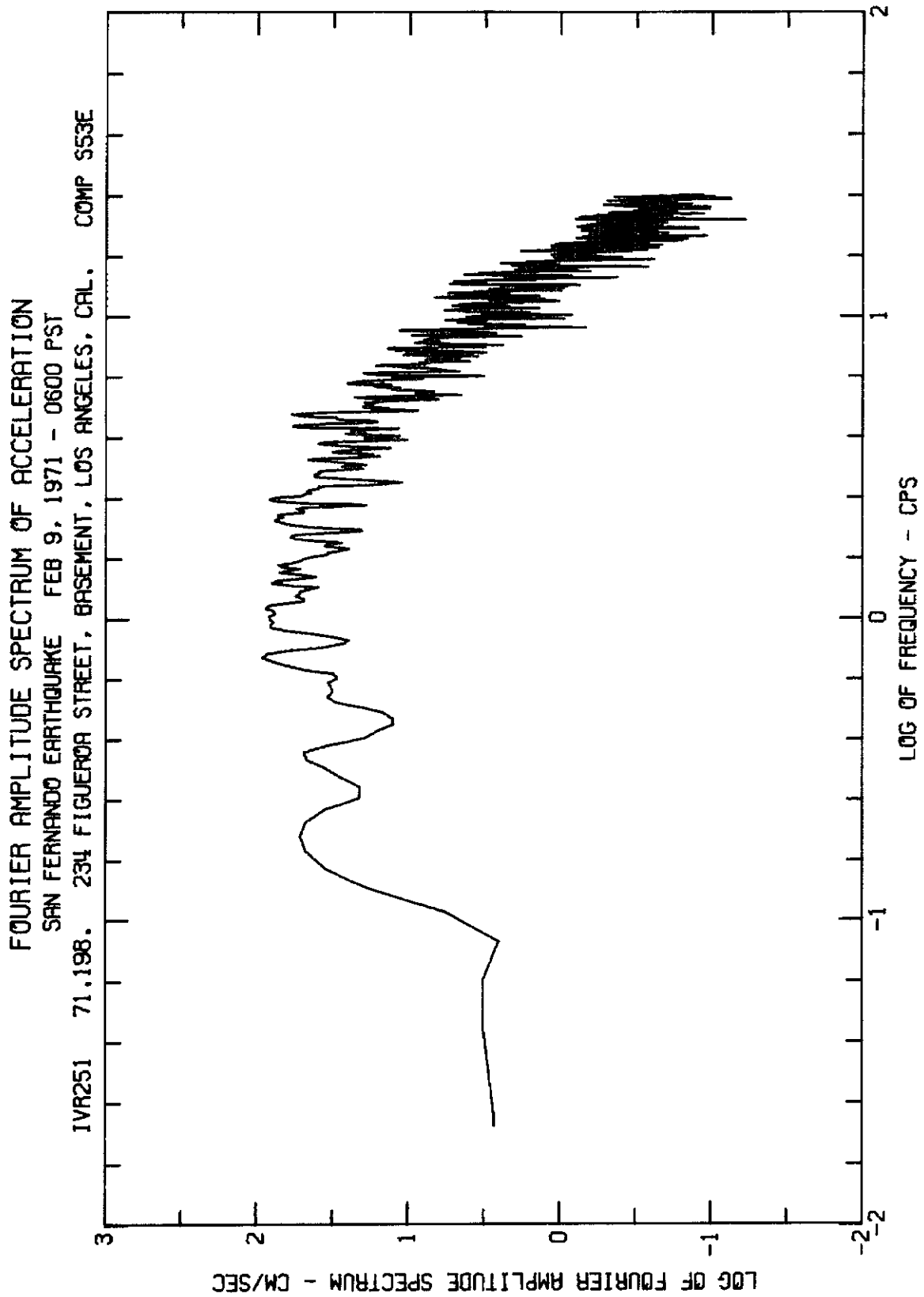


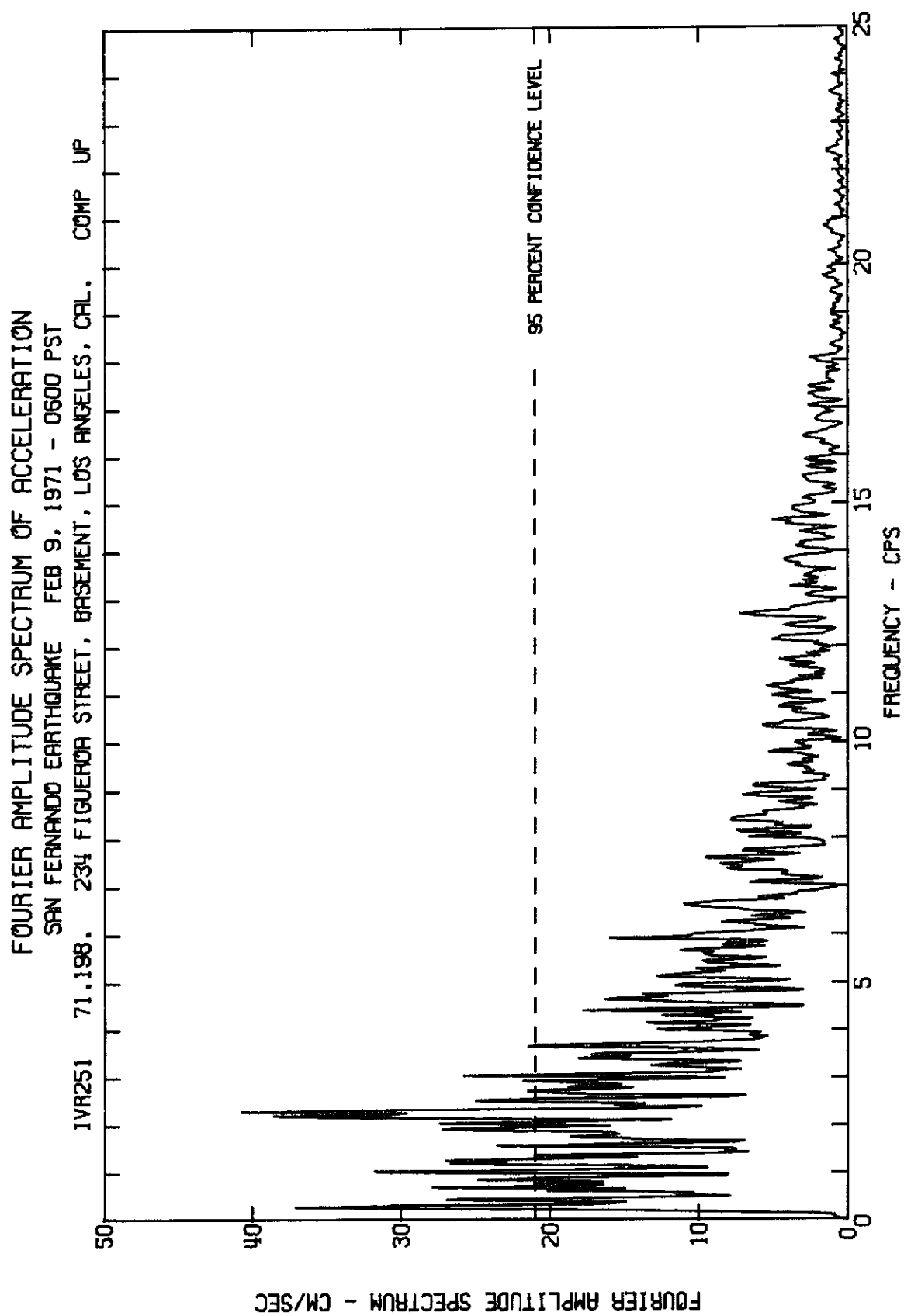


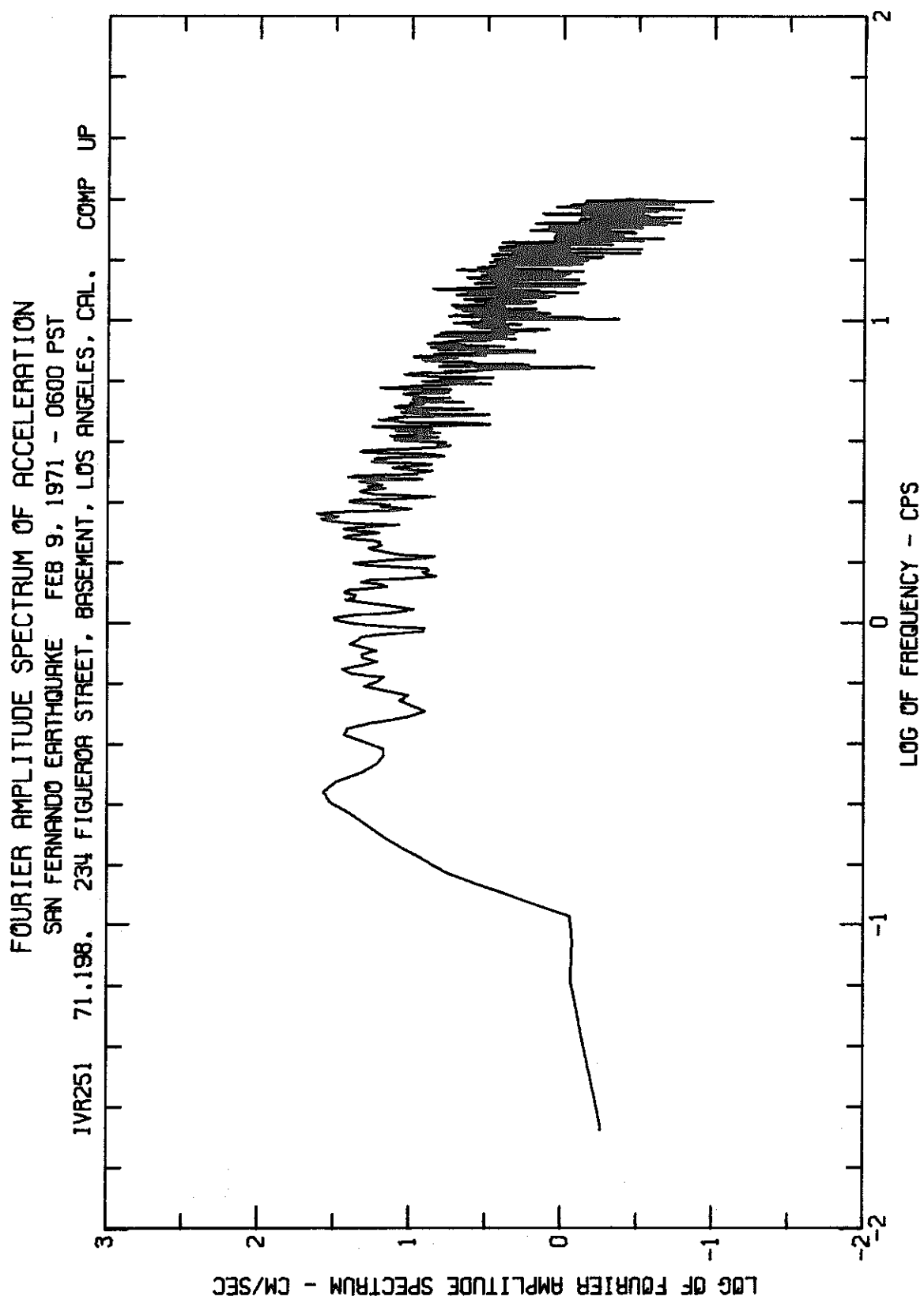








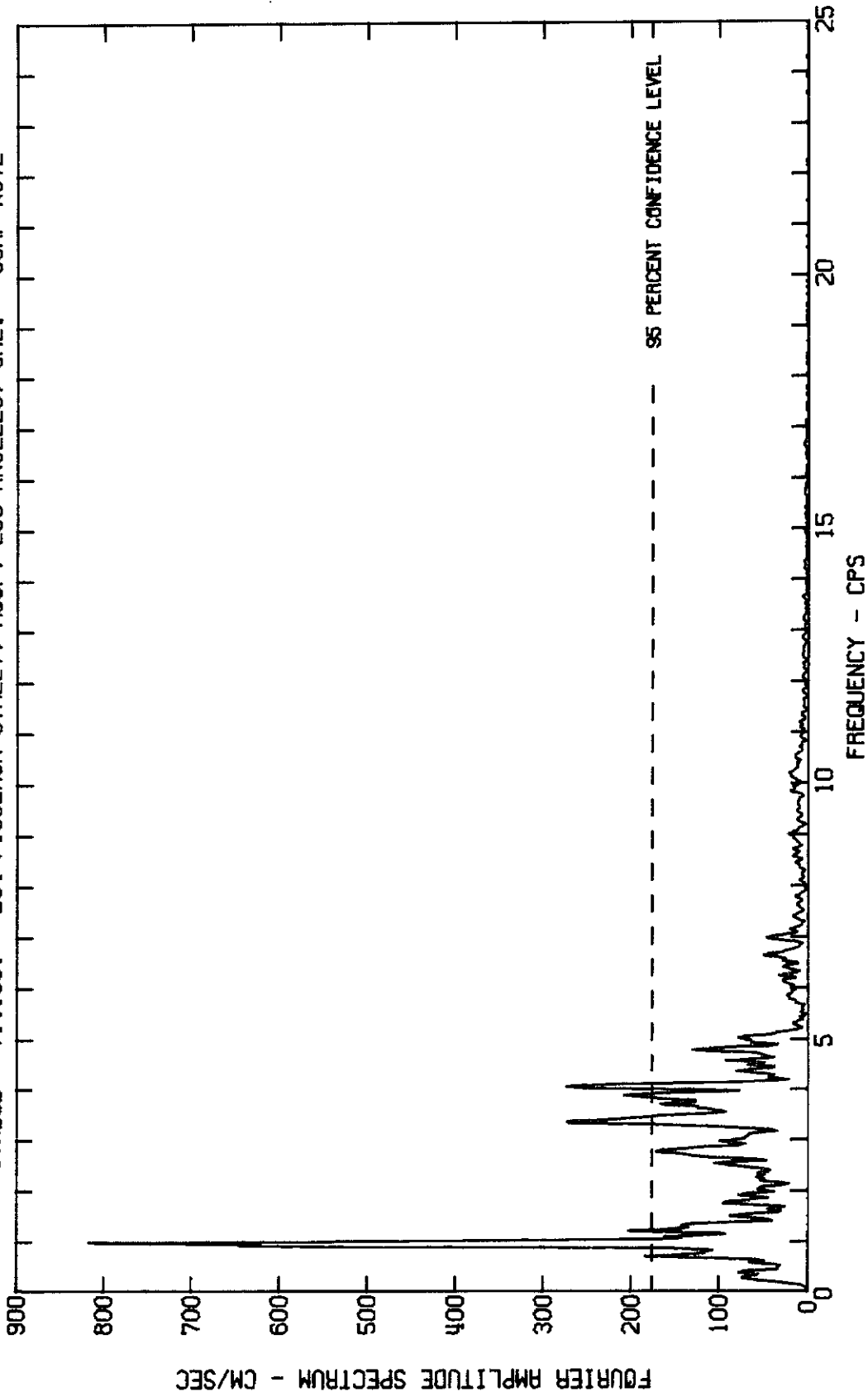


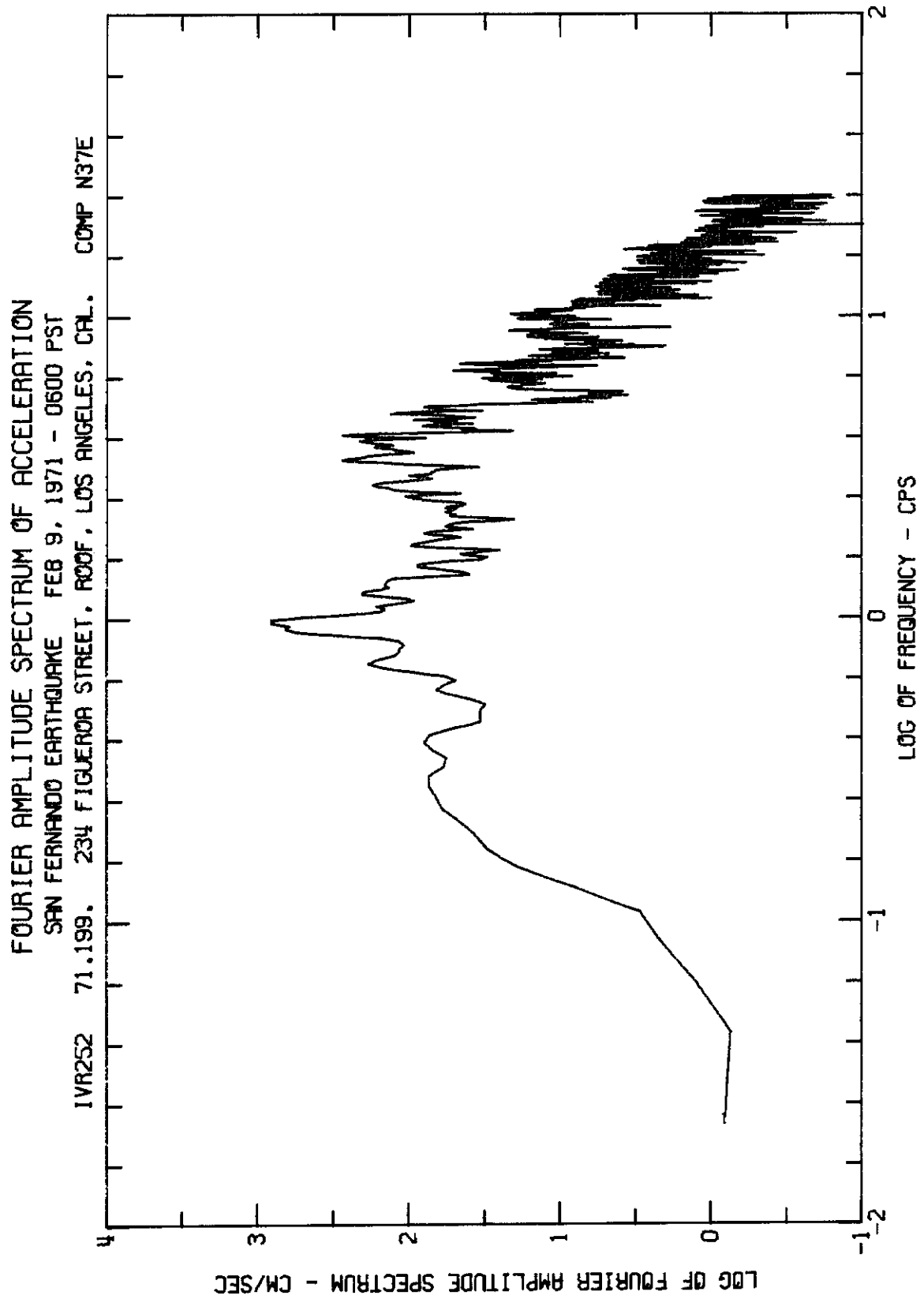


FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

IVR252 71.199. 234 FIGUEROA STREET, ROOF, LOS ANGELES, CAL. COMP N37E

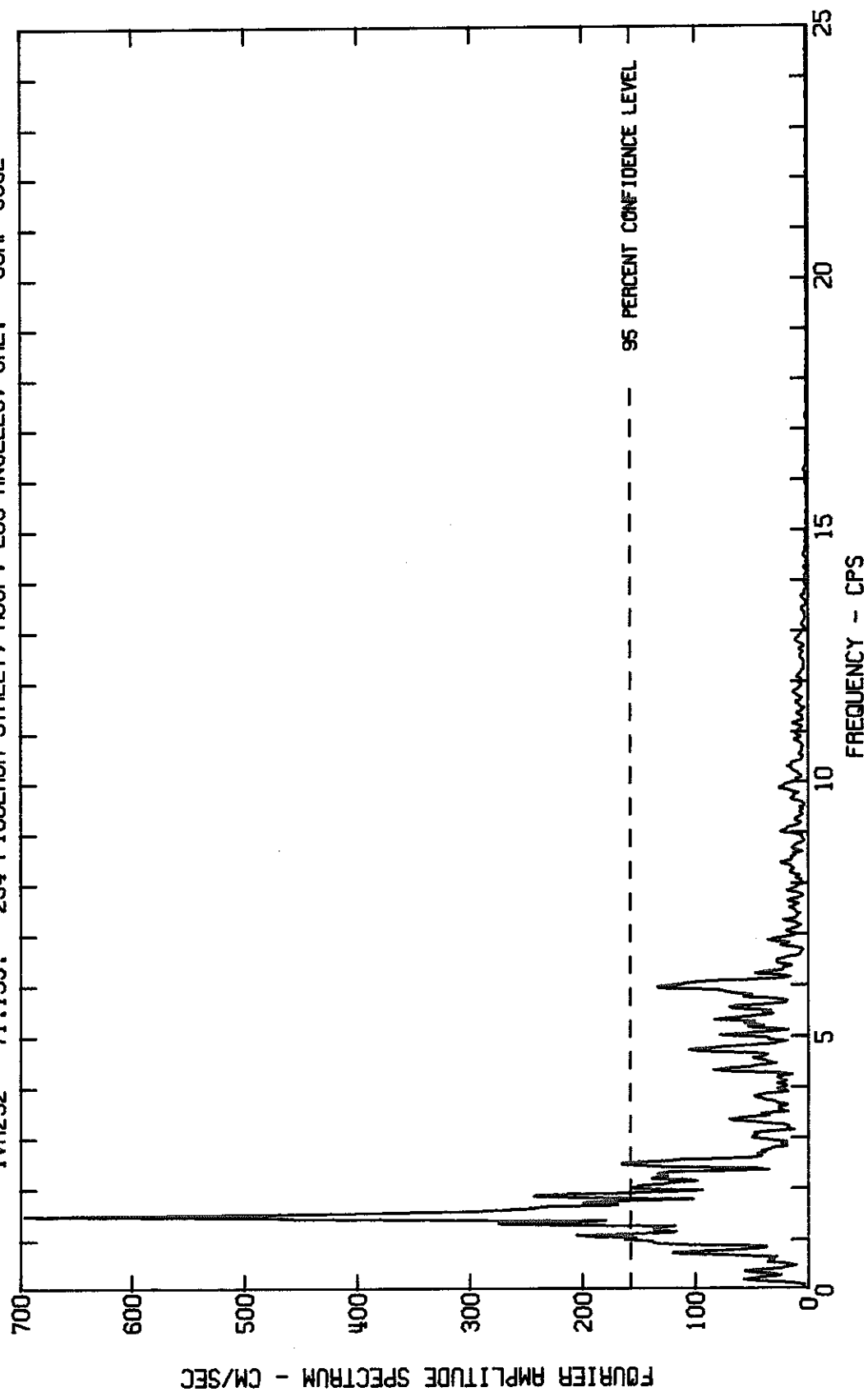




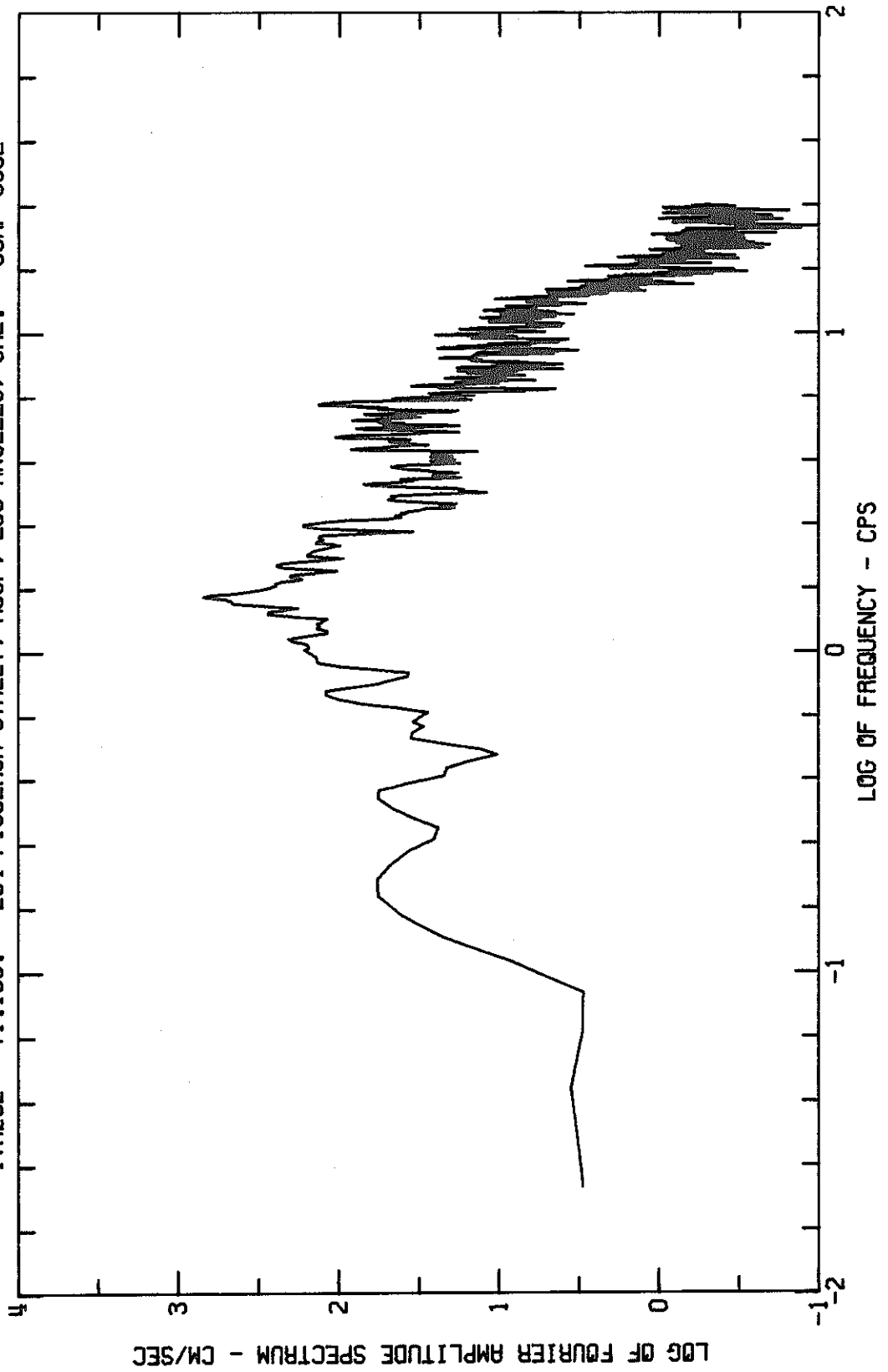
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

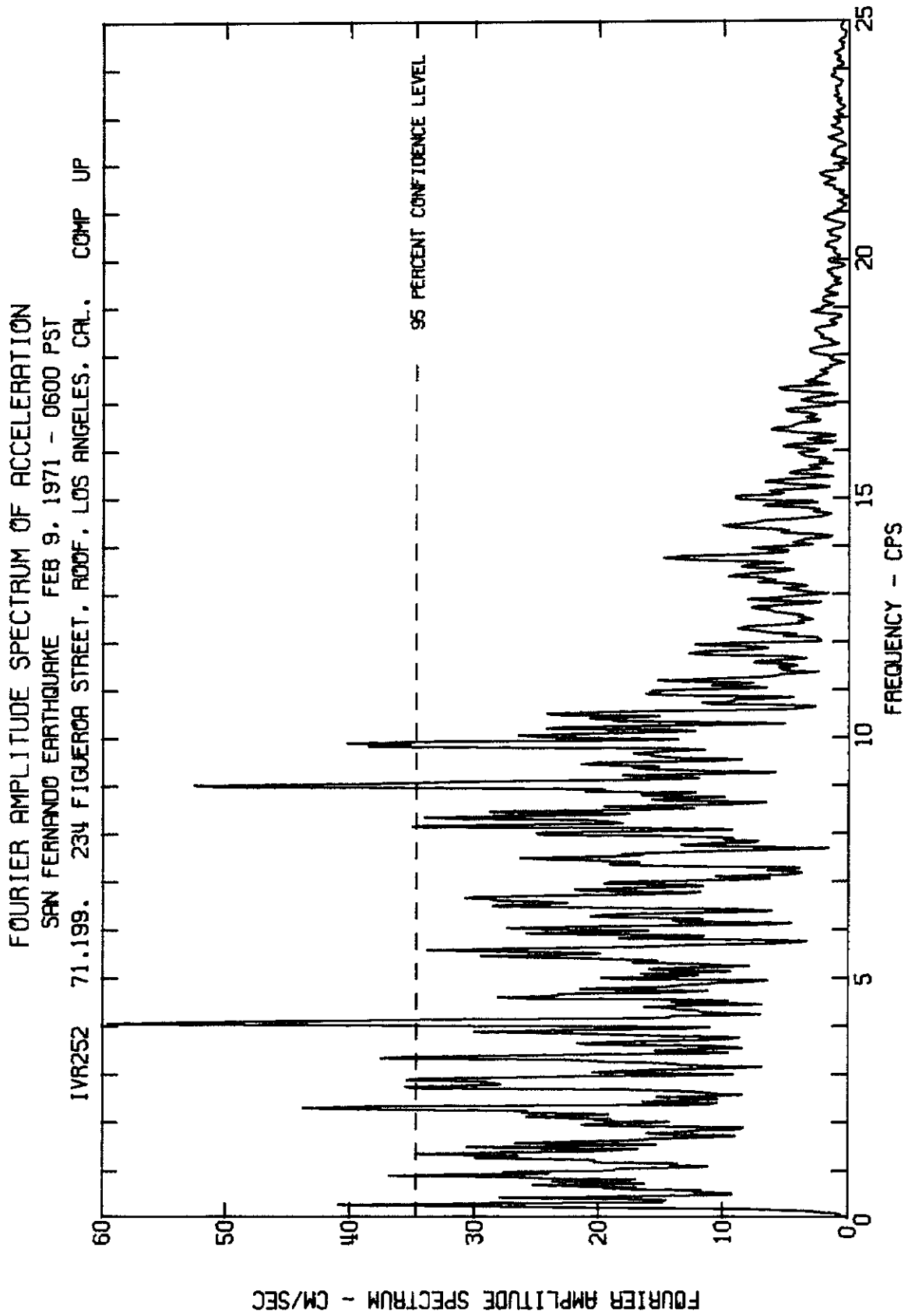
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

1VR252 71.199. 234 FIGUEROA STREET, ROOF. LOS ANGELES, CAL. COMP S53E

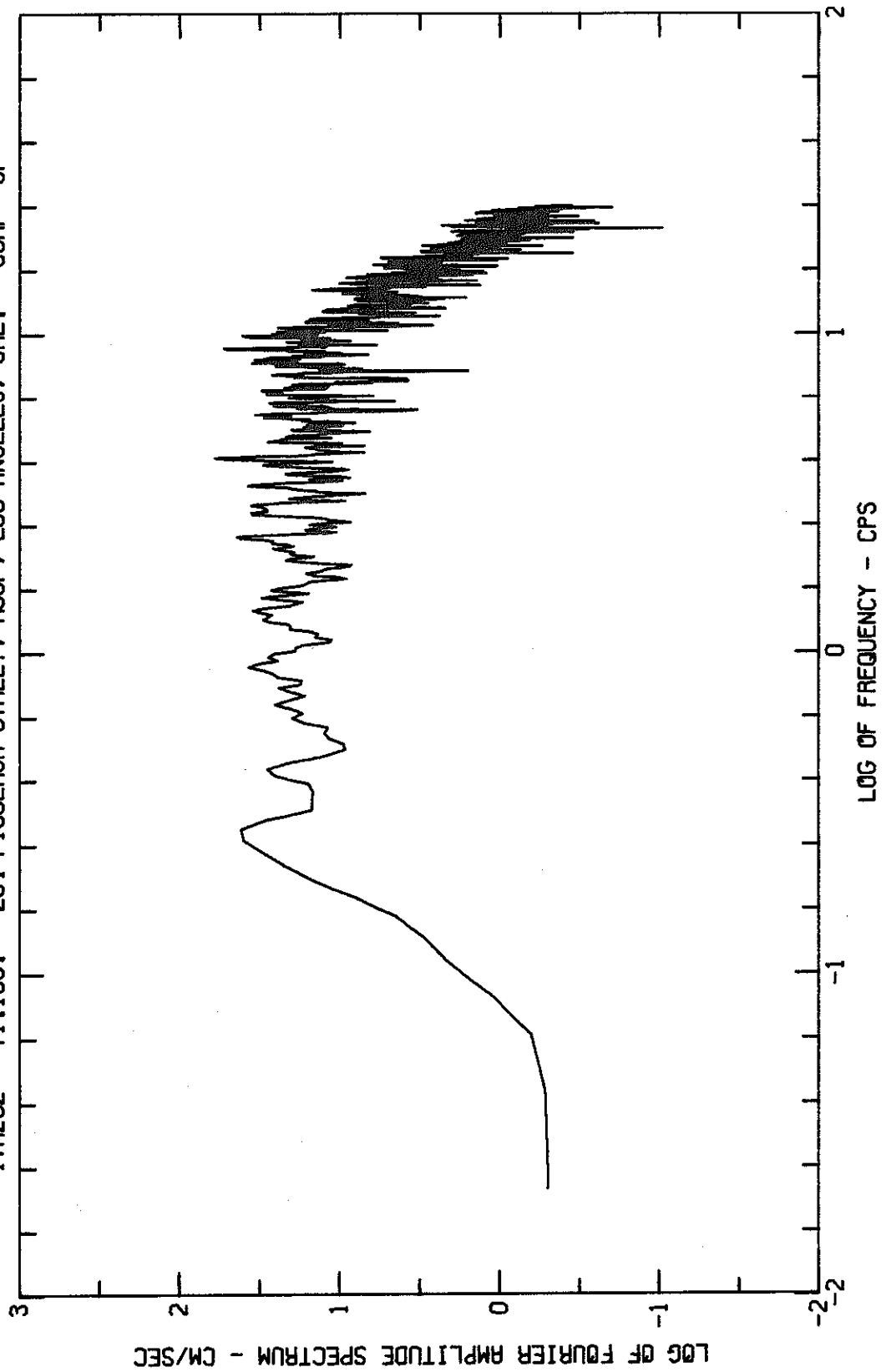


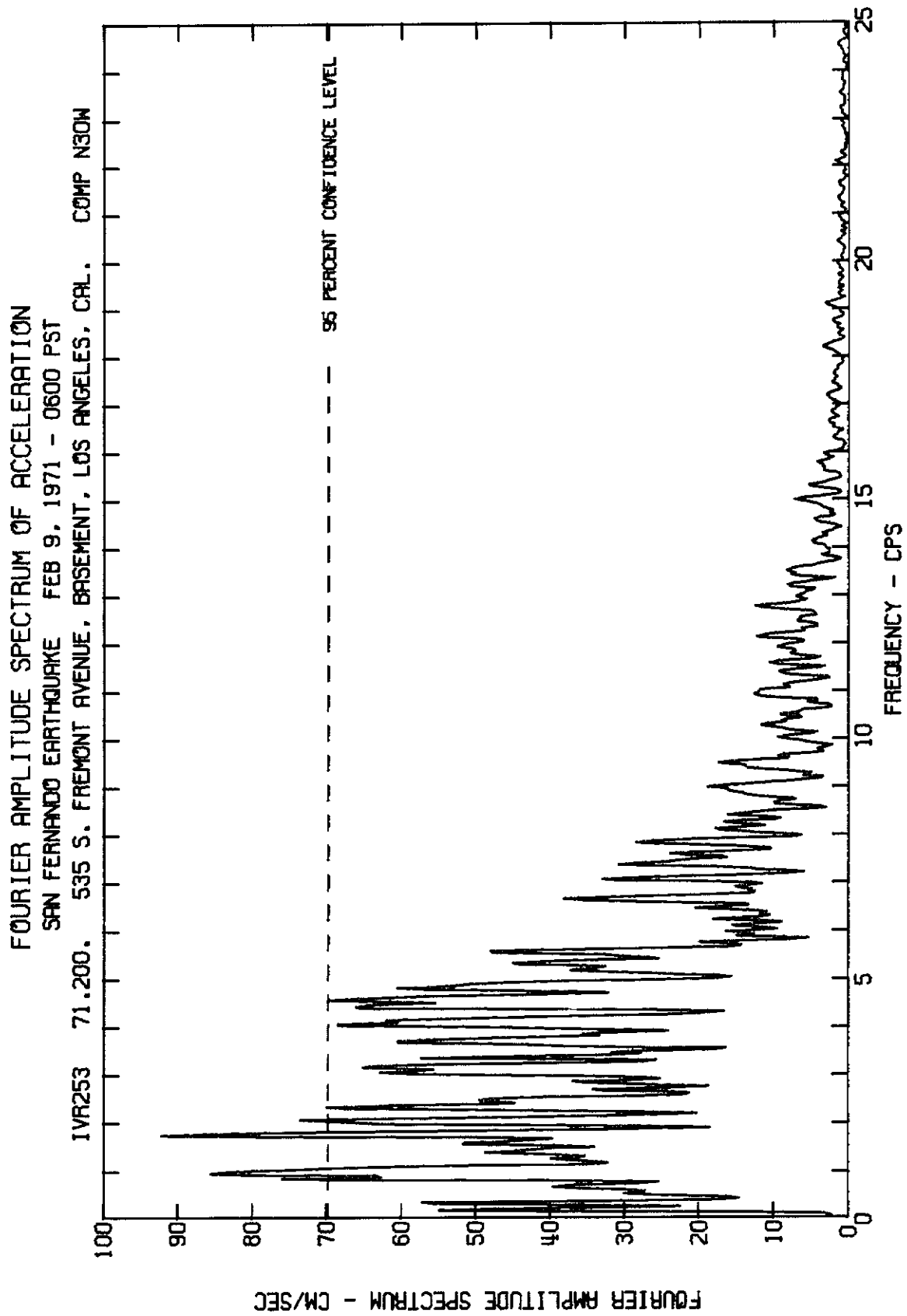
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST
1VR252 71.199. 234 FIGUEROA STREET, ROOF, LOS ANGELES, CAL. COMP S53E

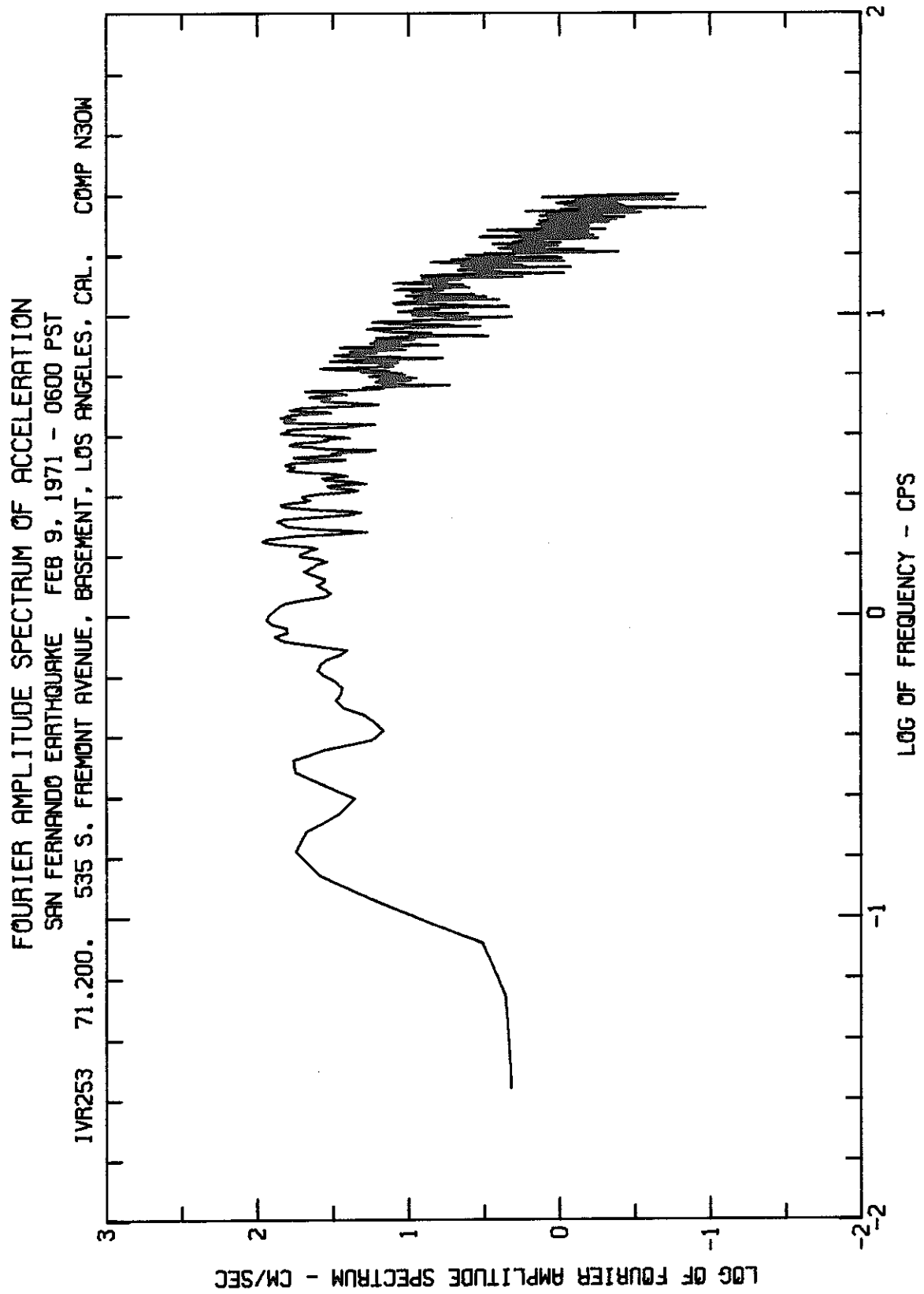


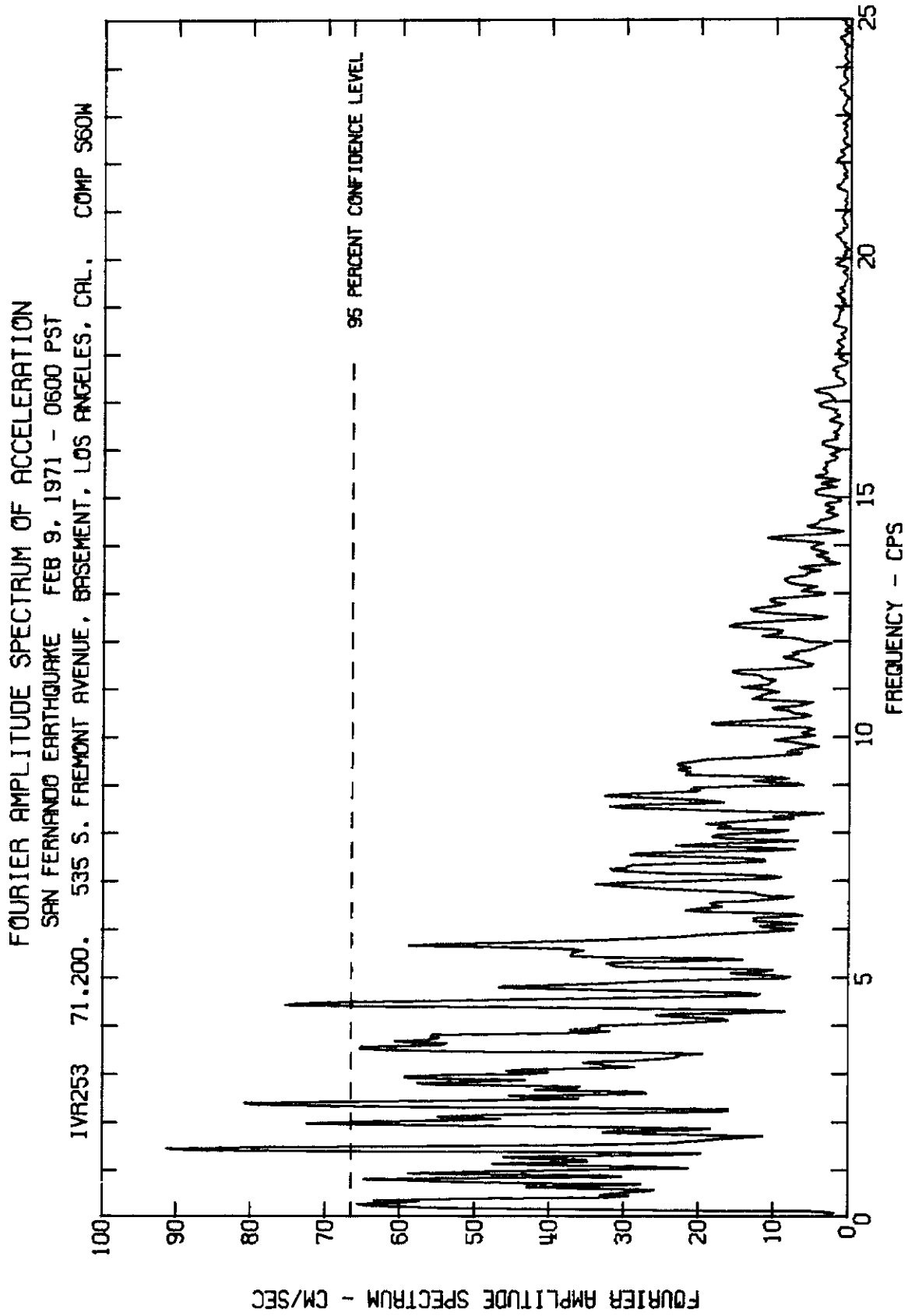


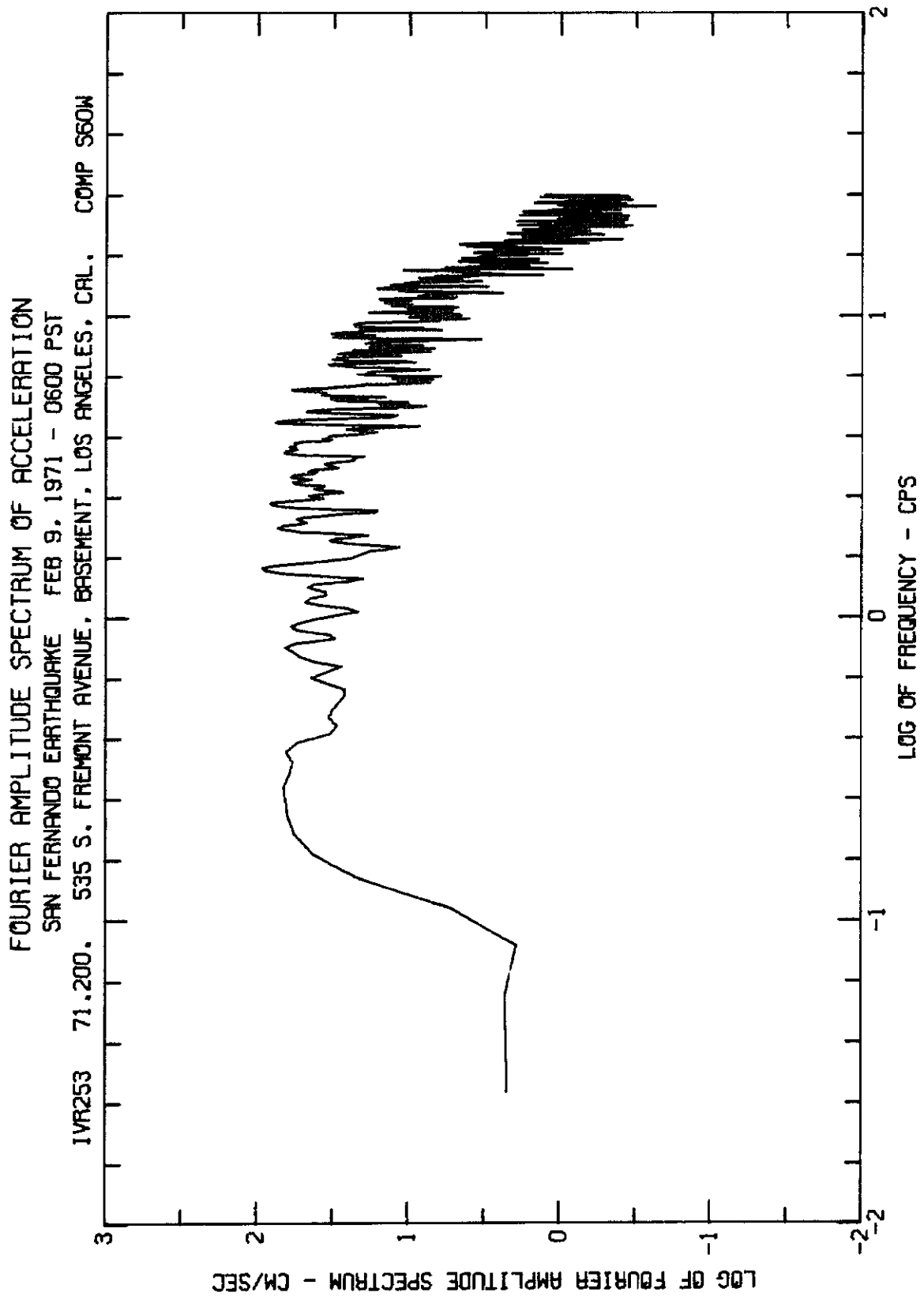
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST
IVR252 71.199. 234 FIGUEROA STREET, ROOF, LOS ANGELES, CAL. COMP UP

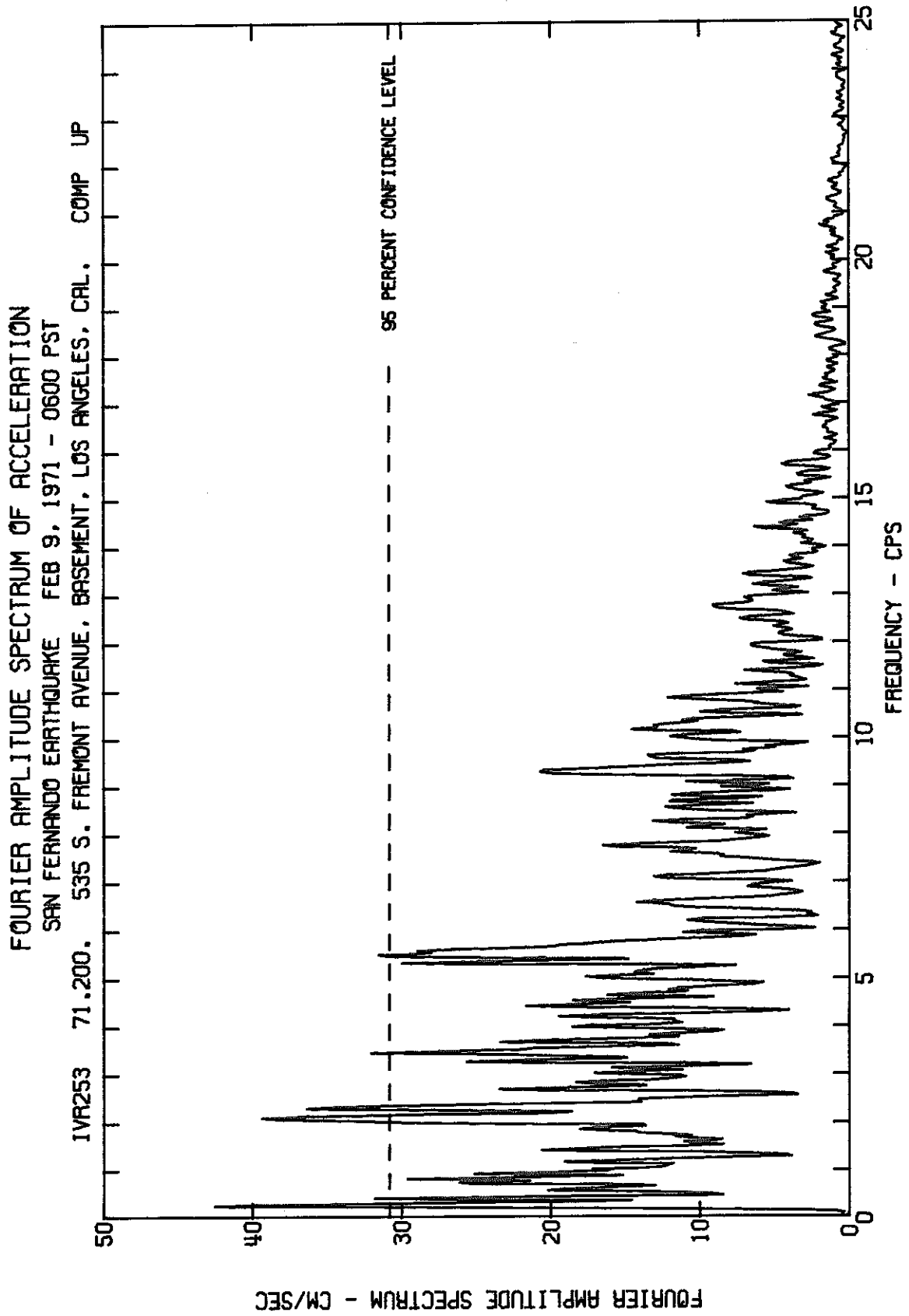


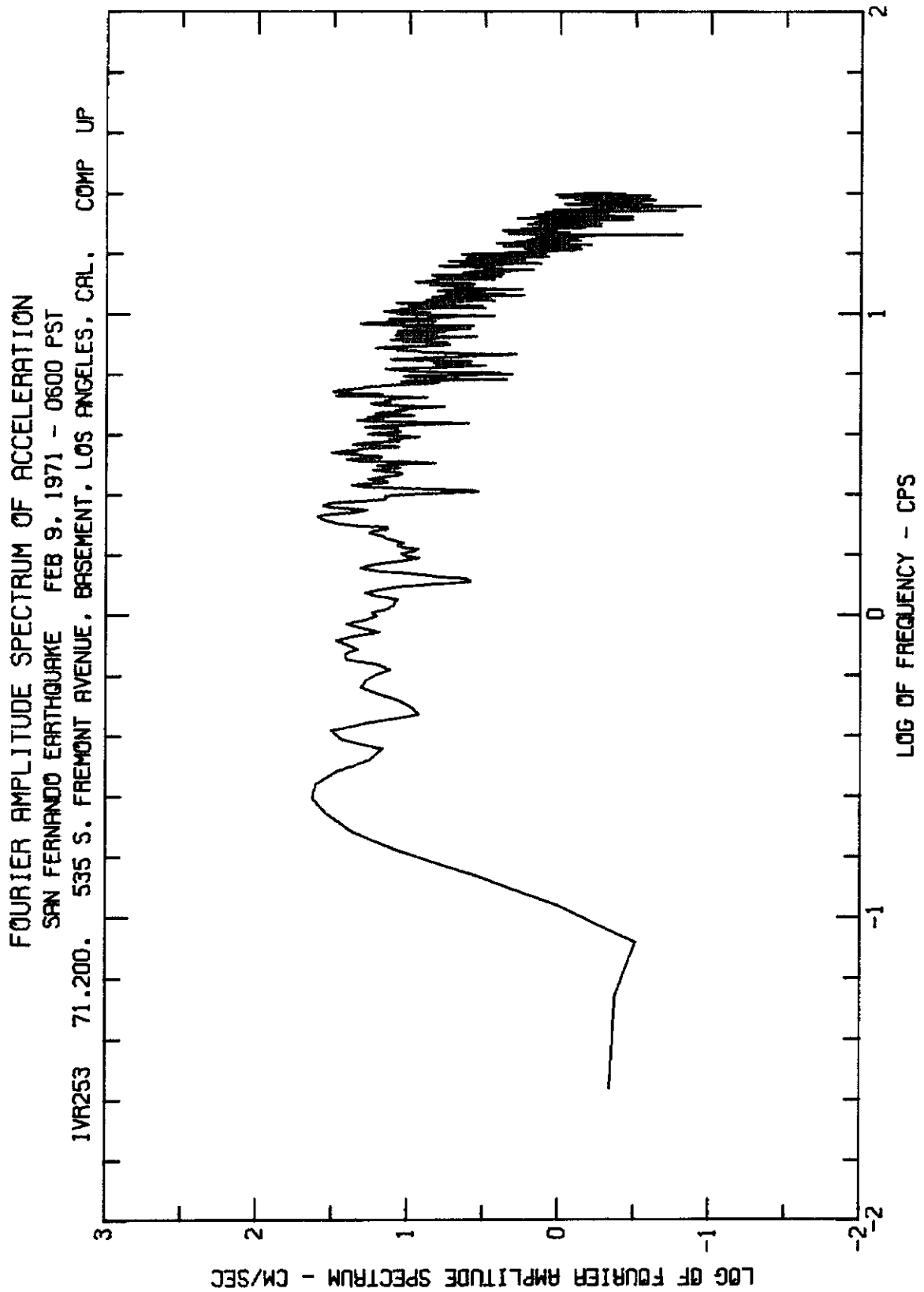


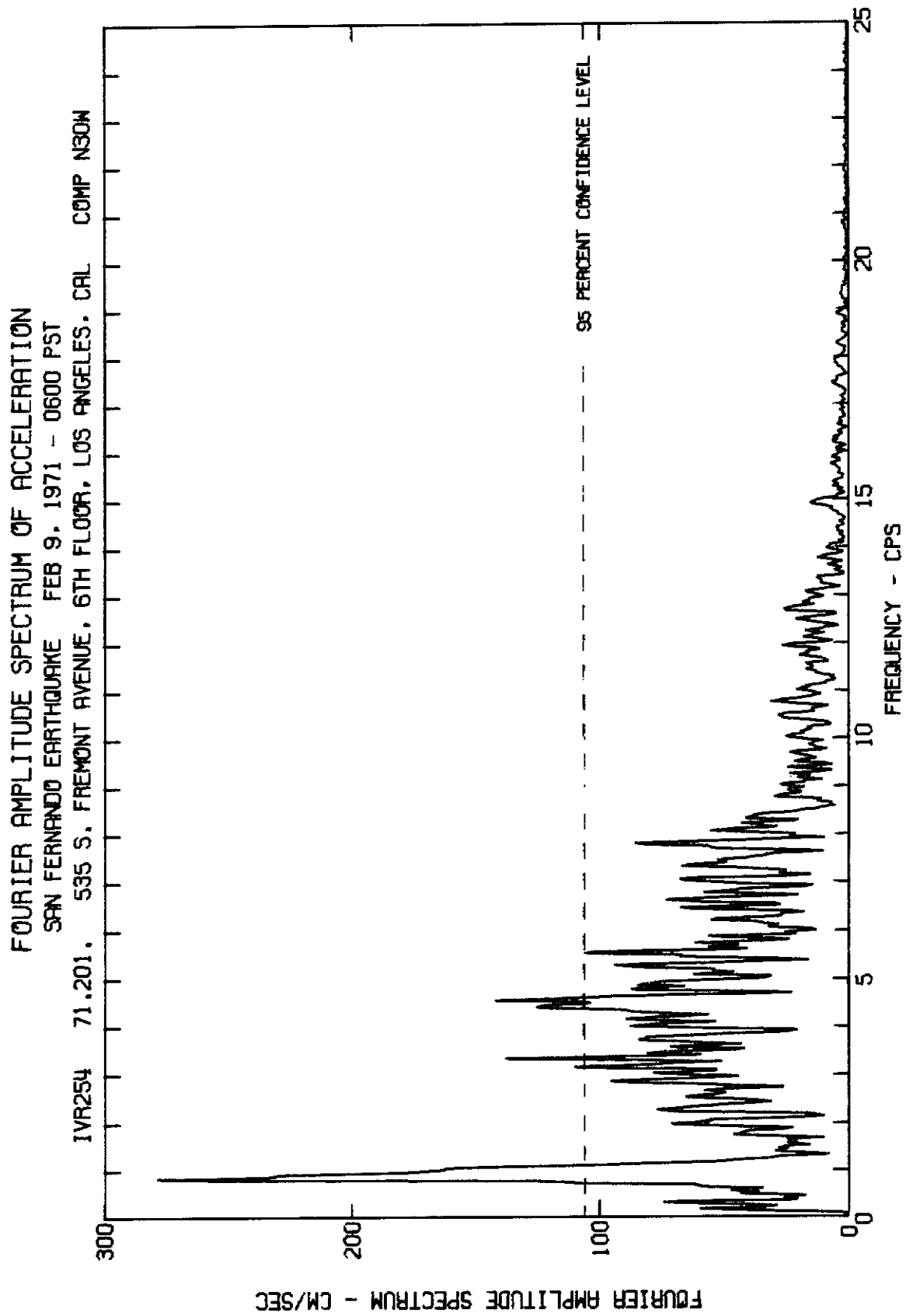


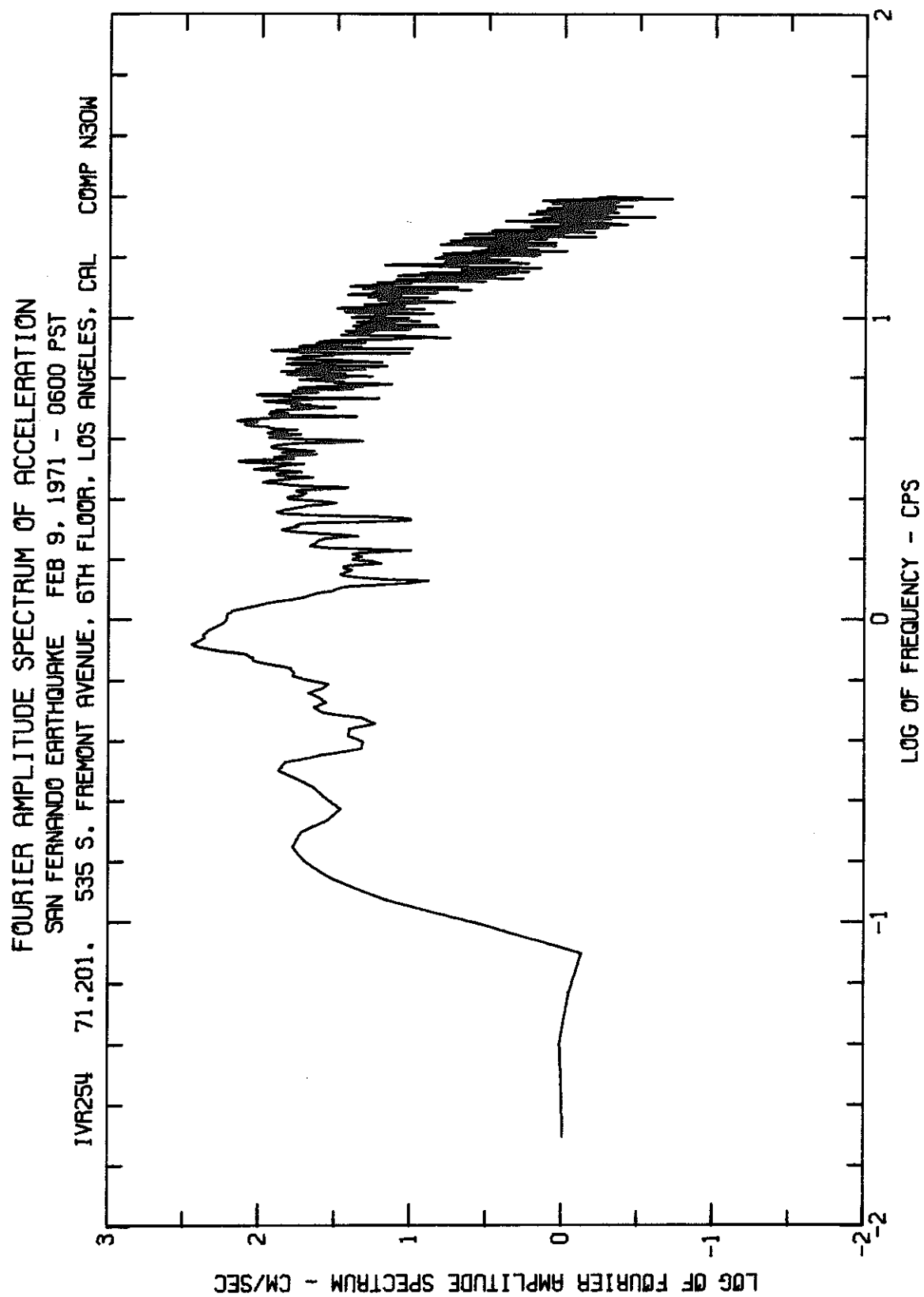


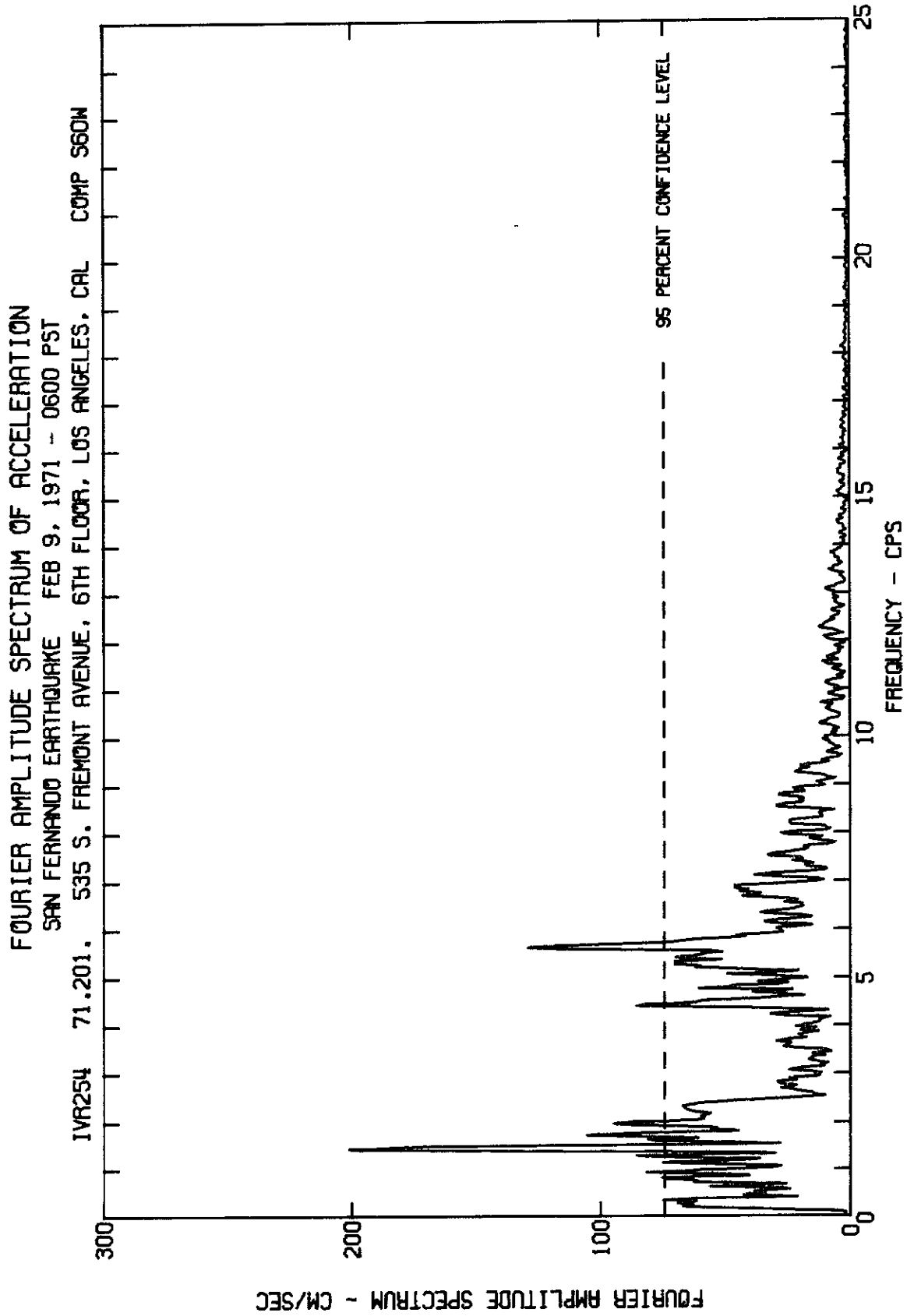


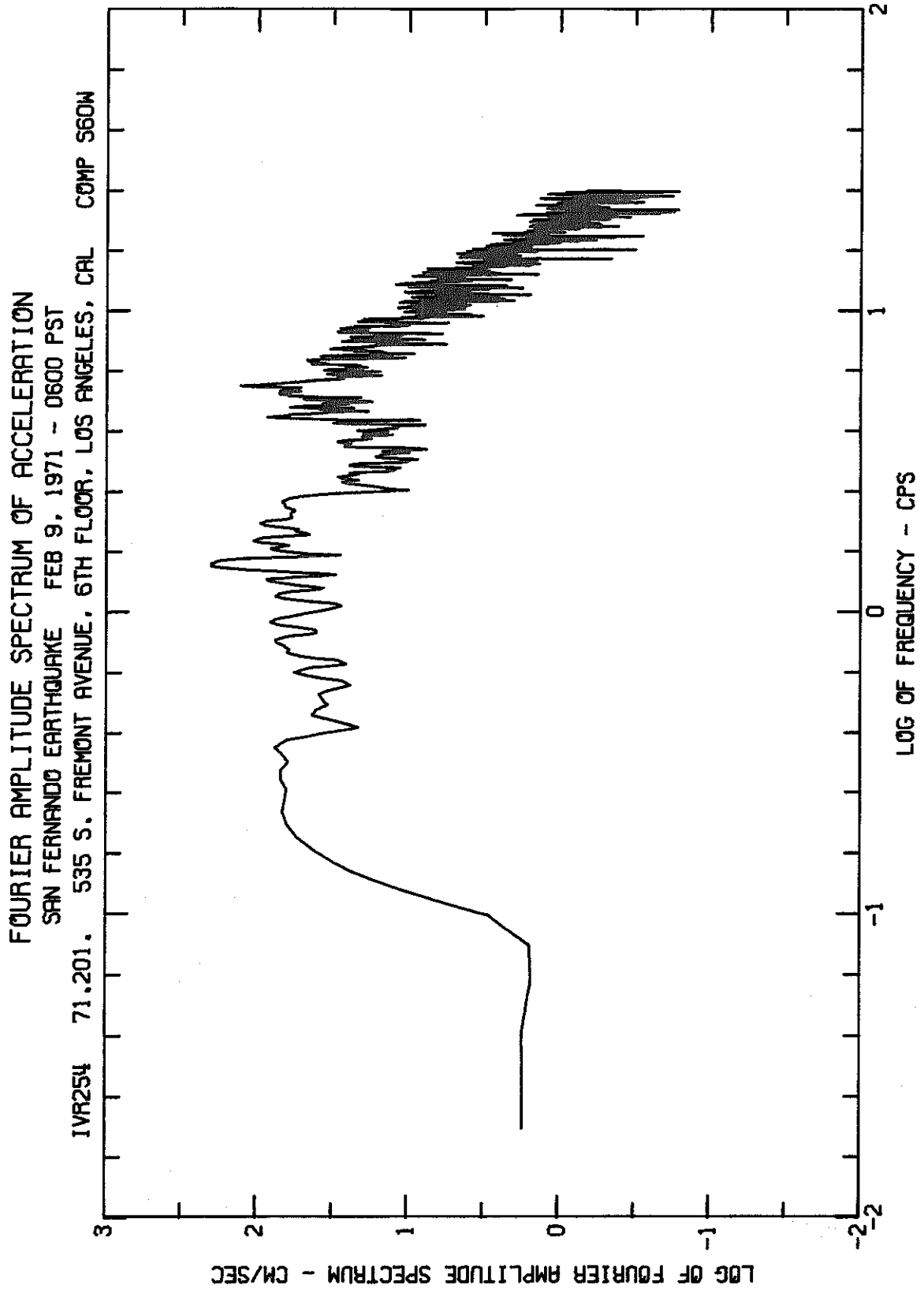


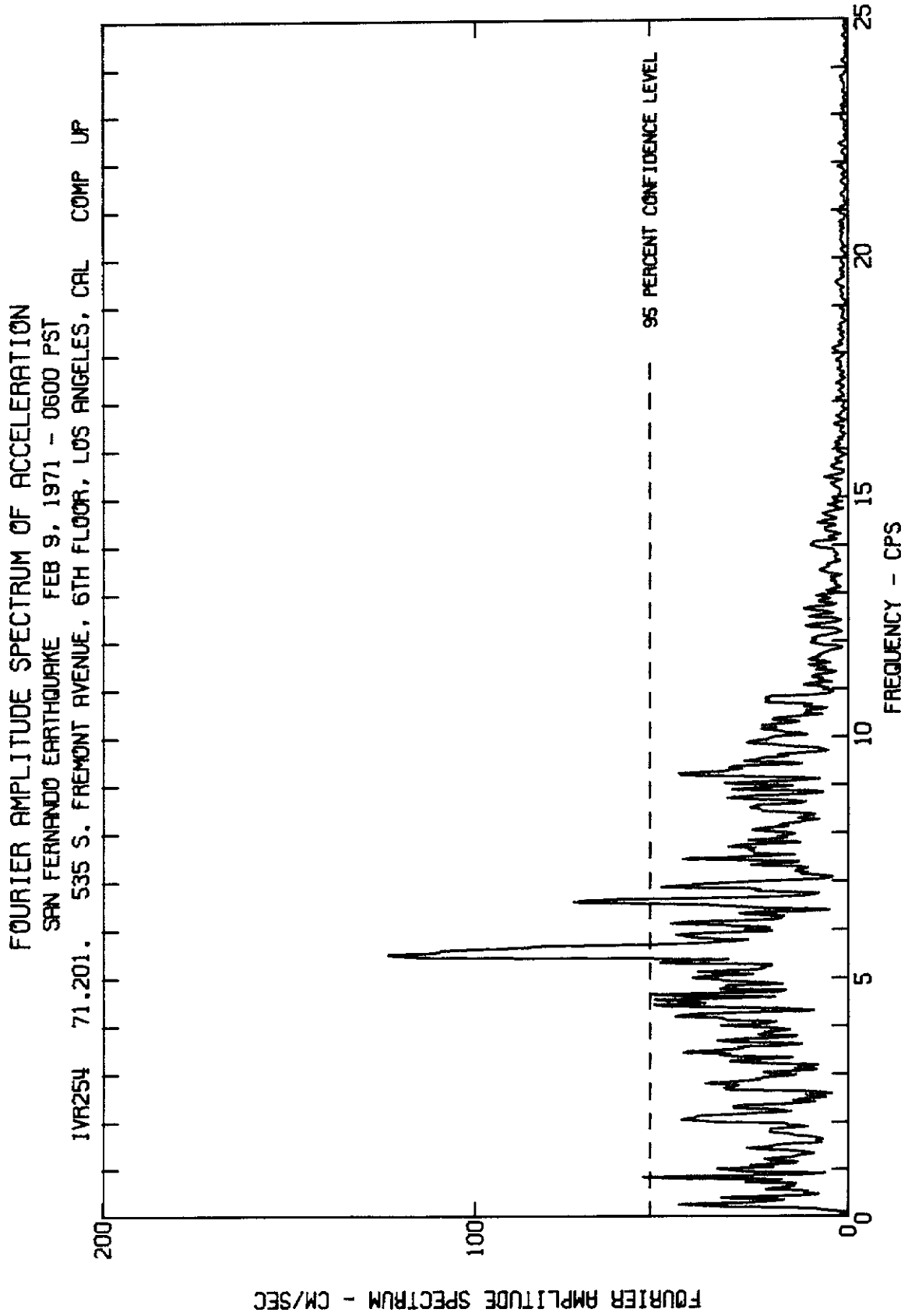


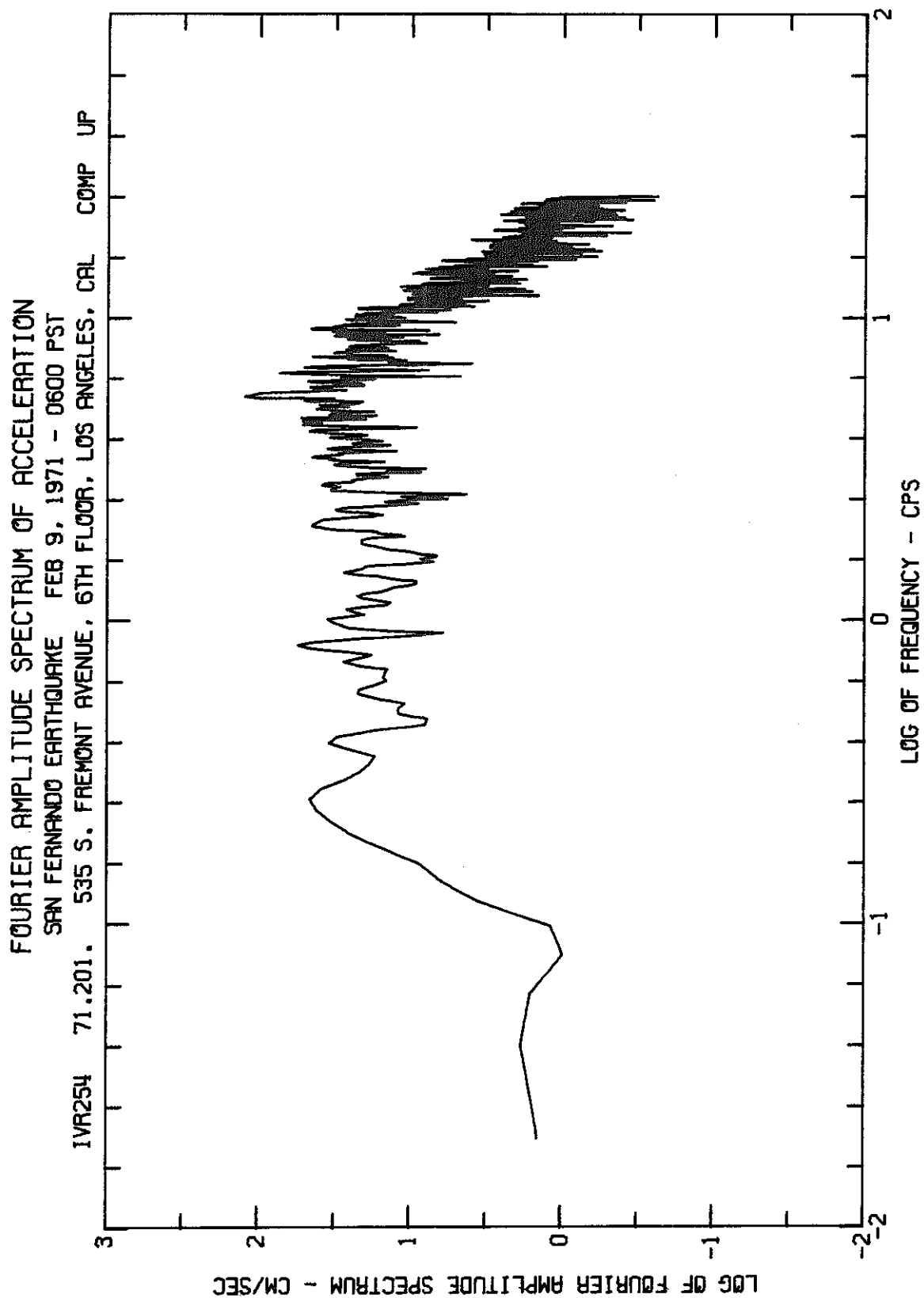


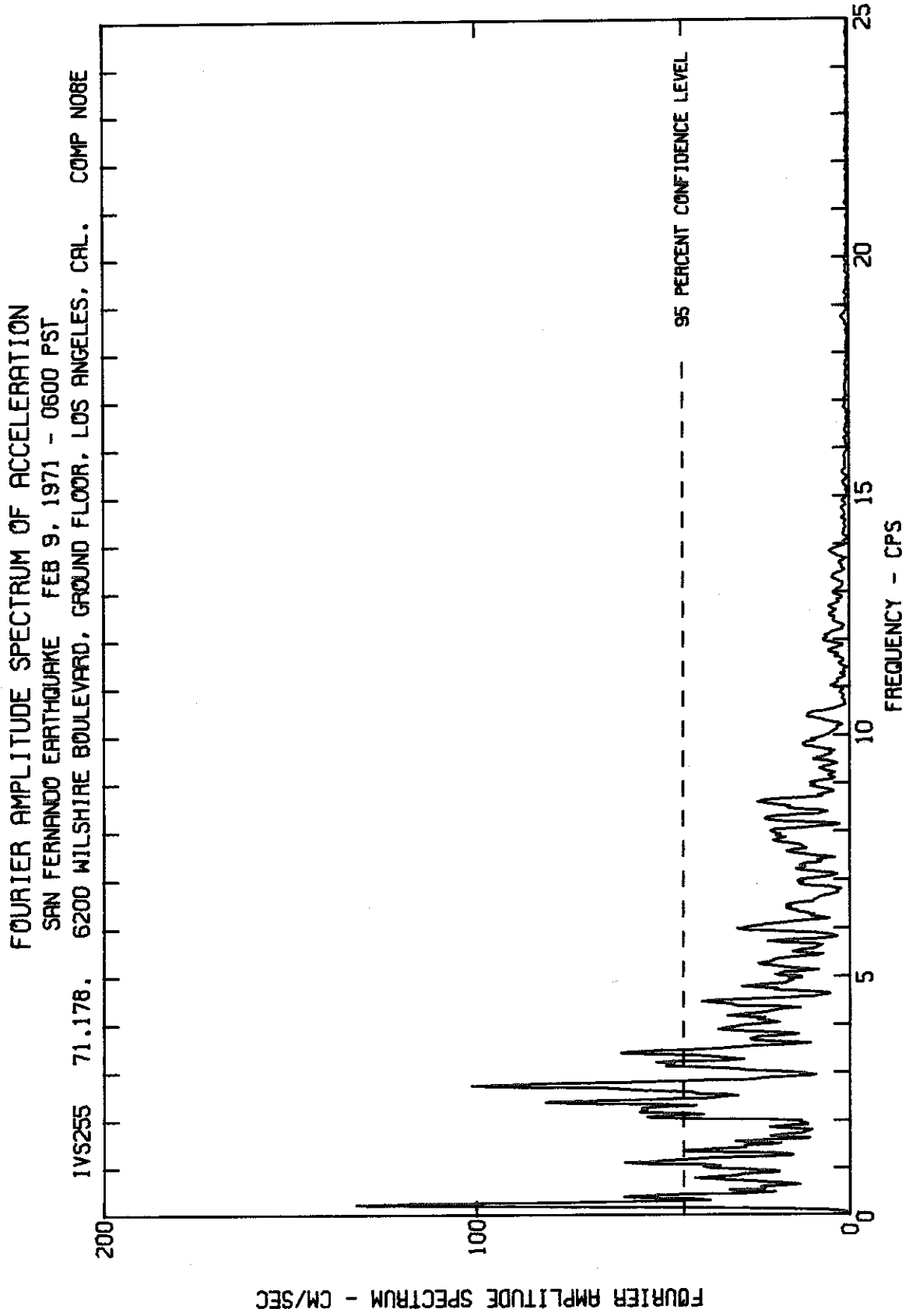


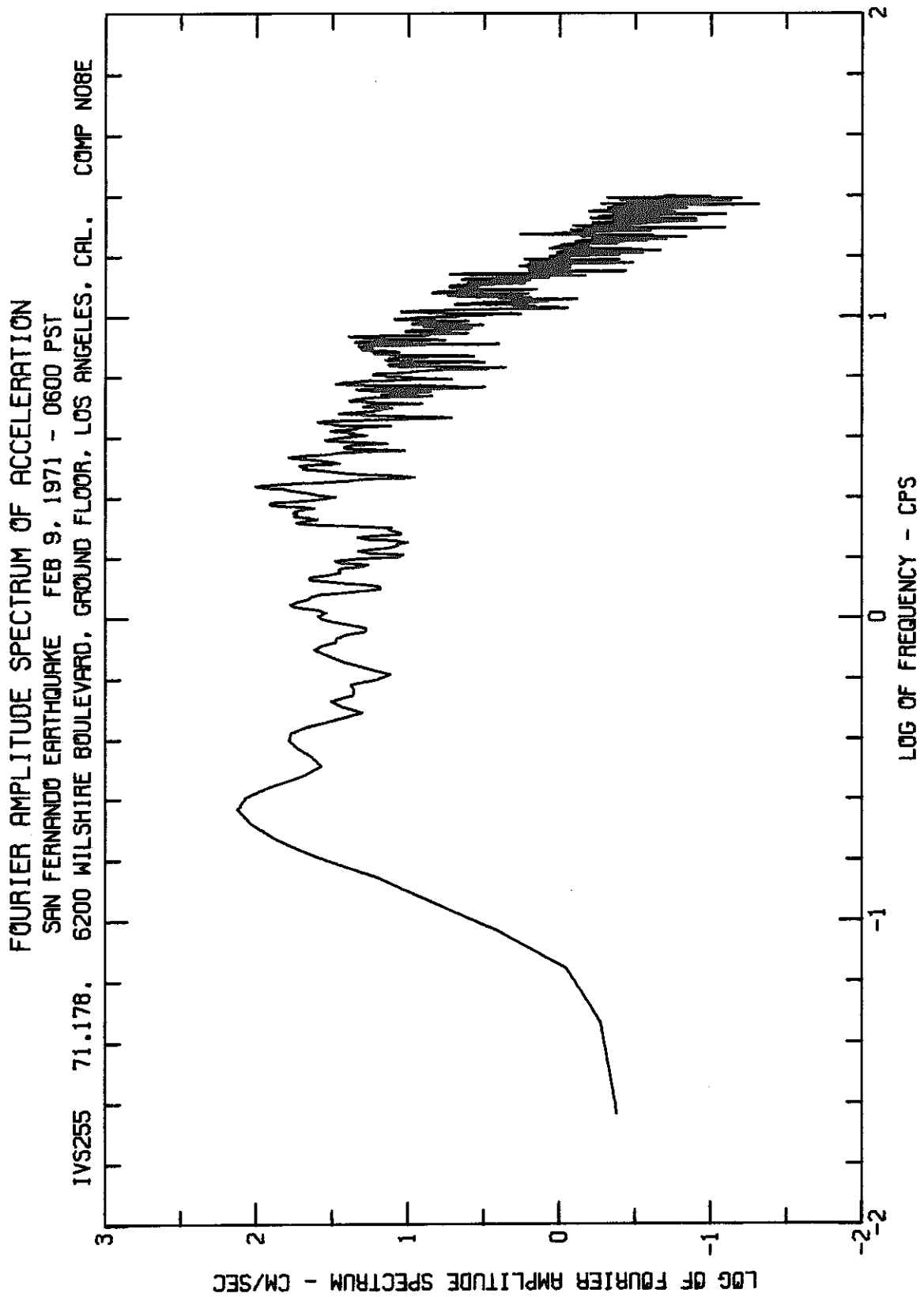


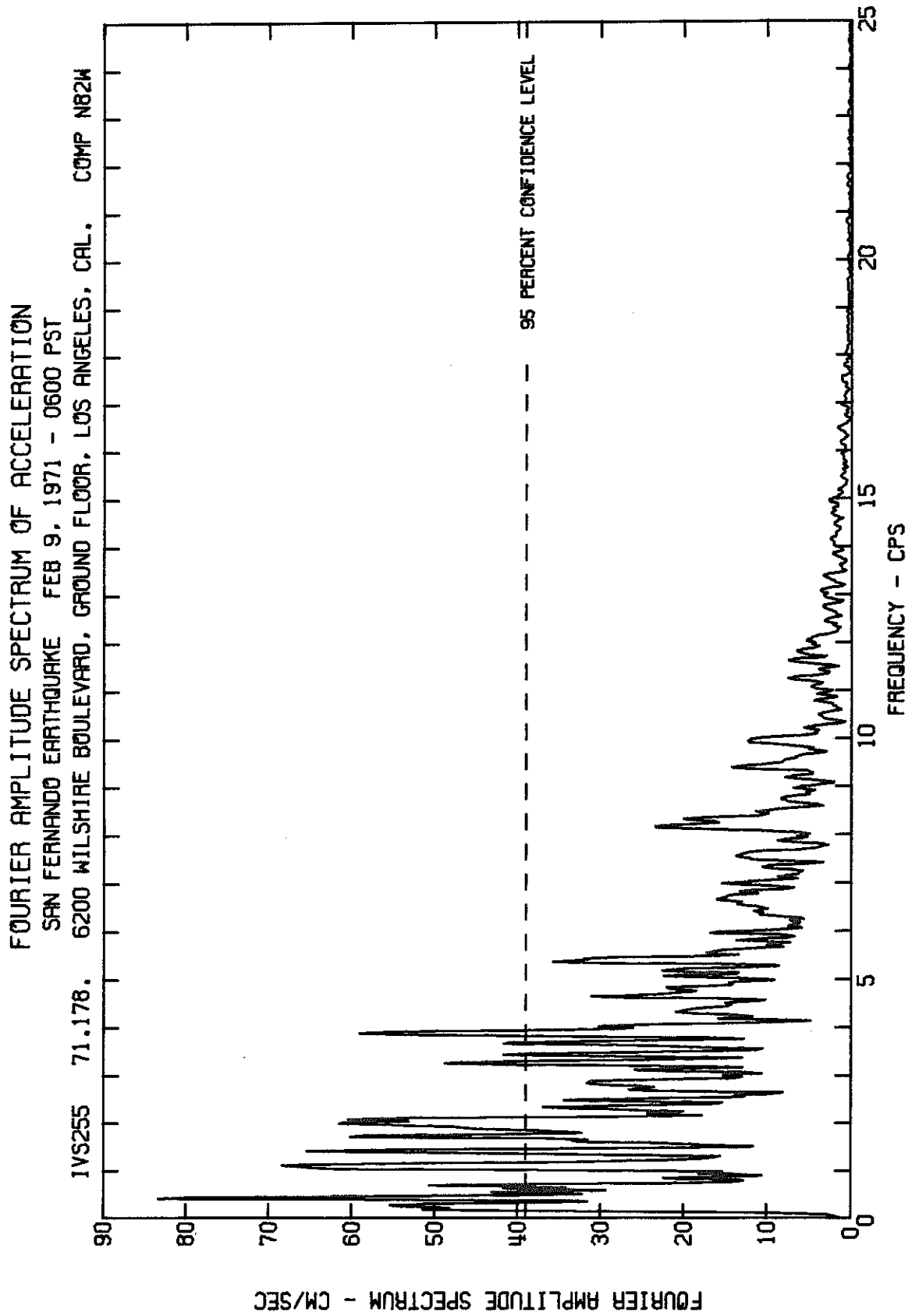


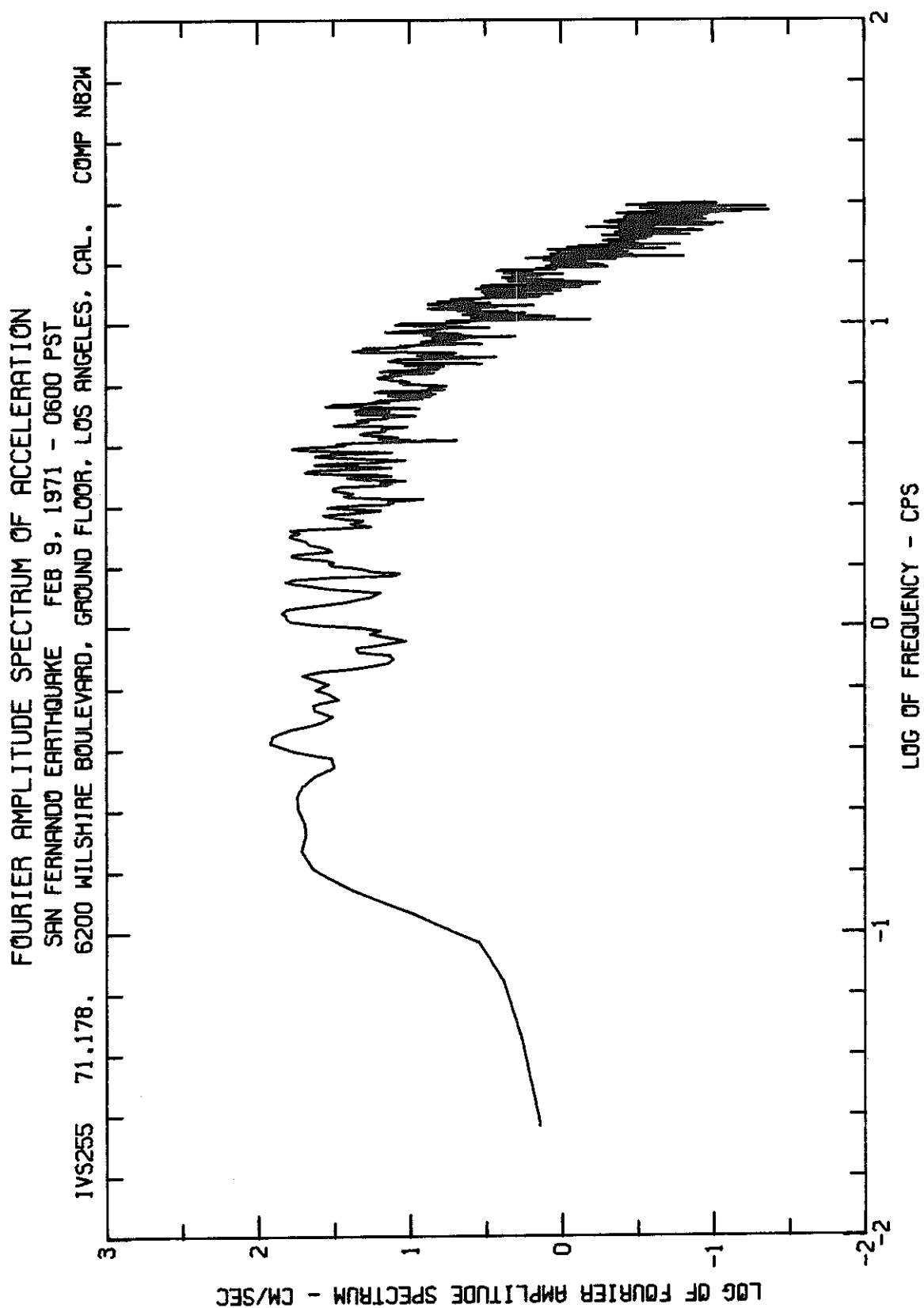


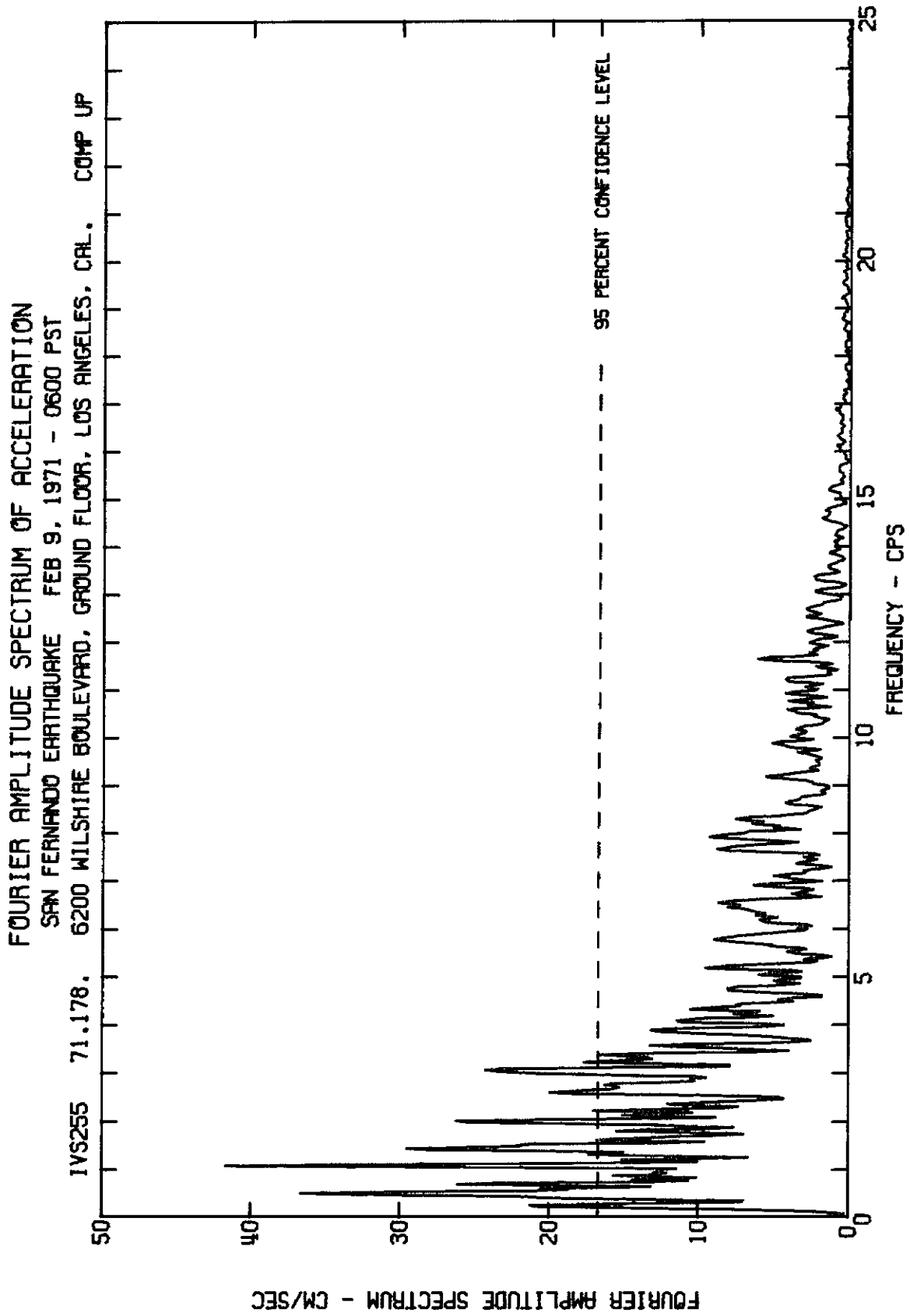


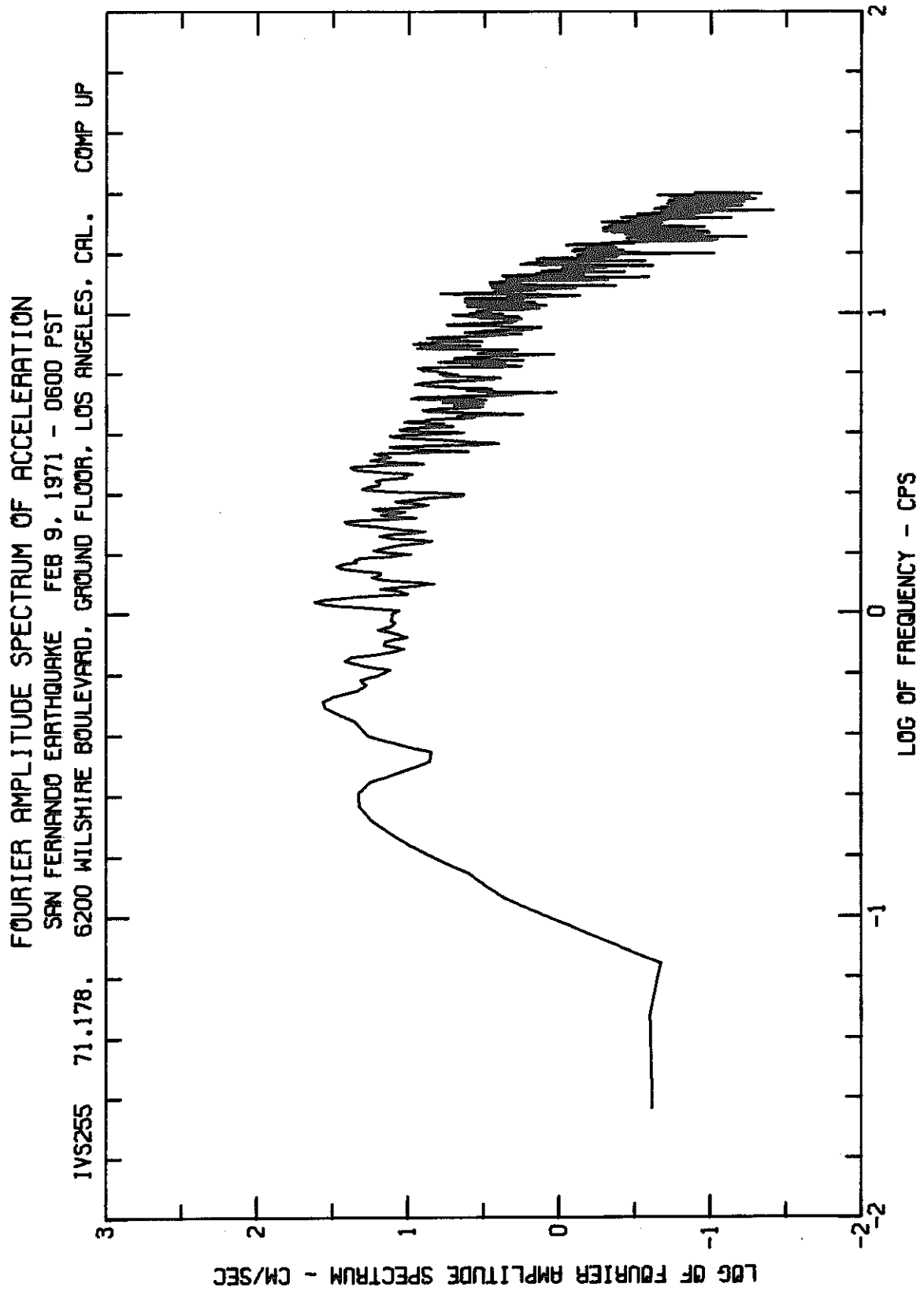


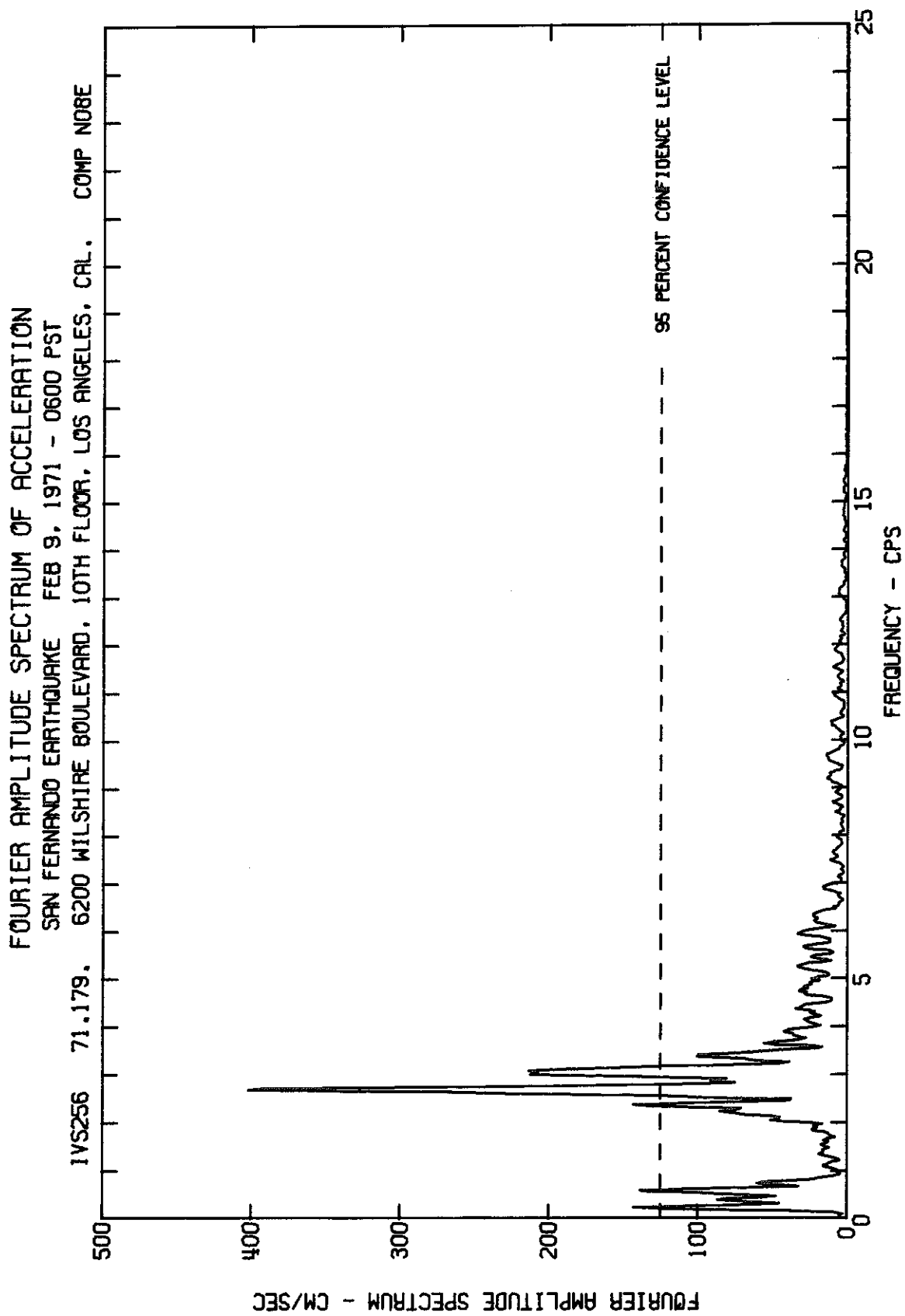


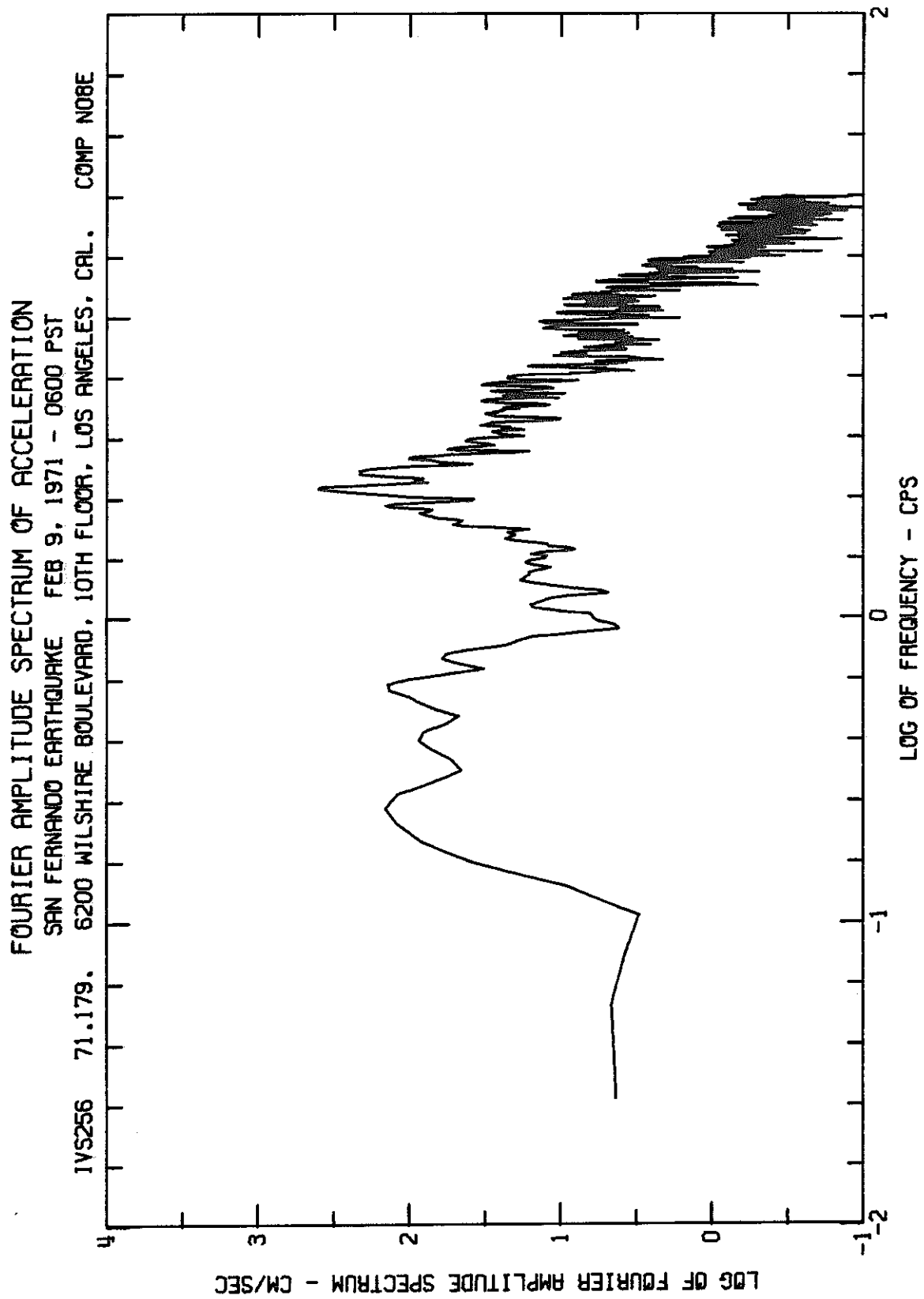








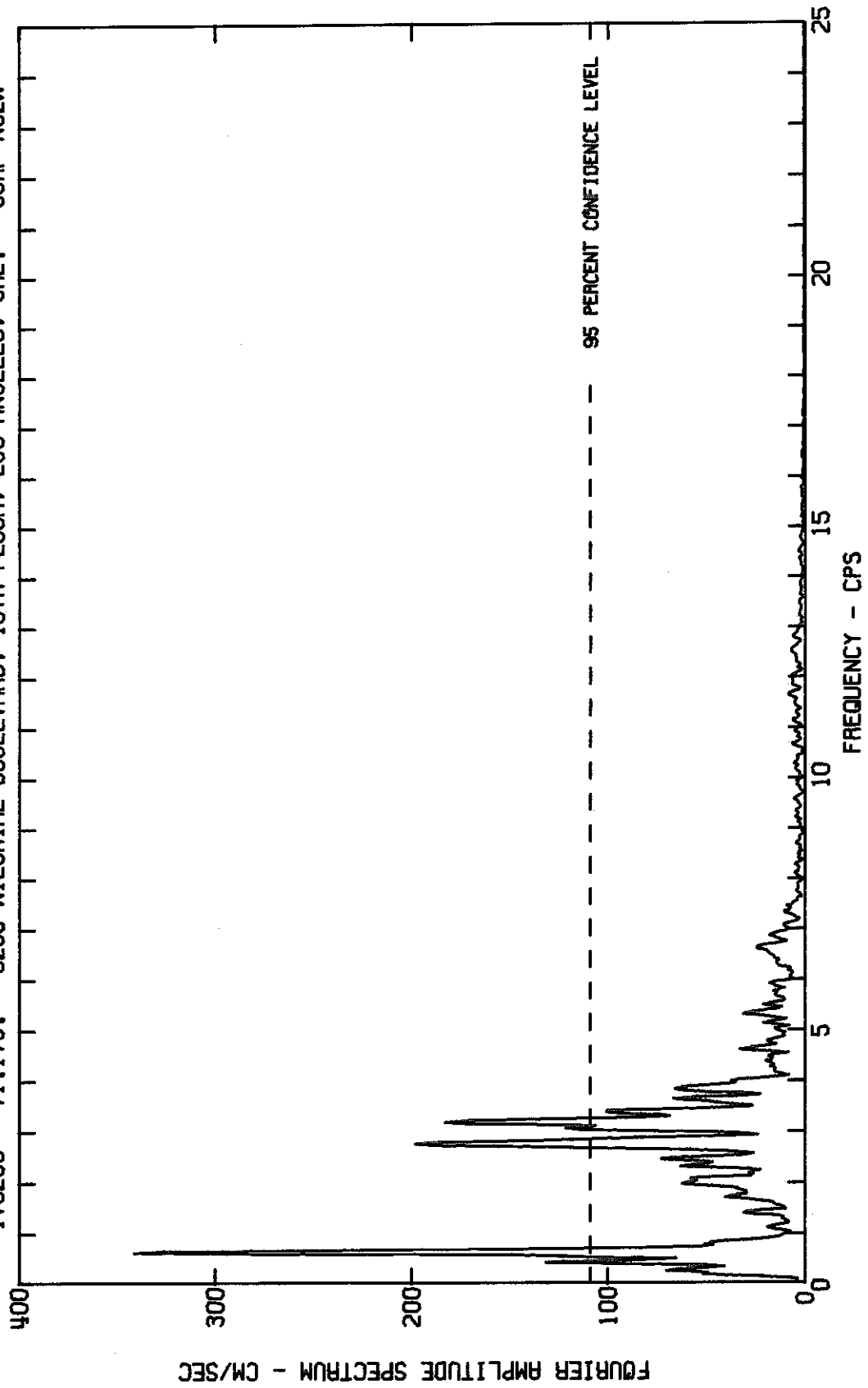


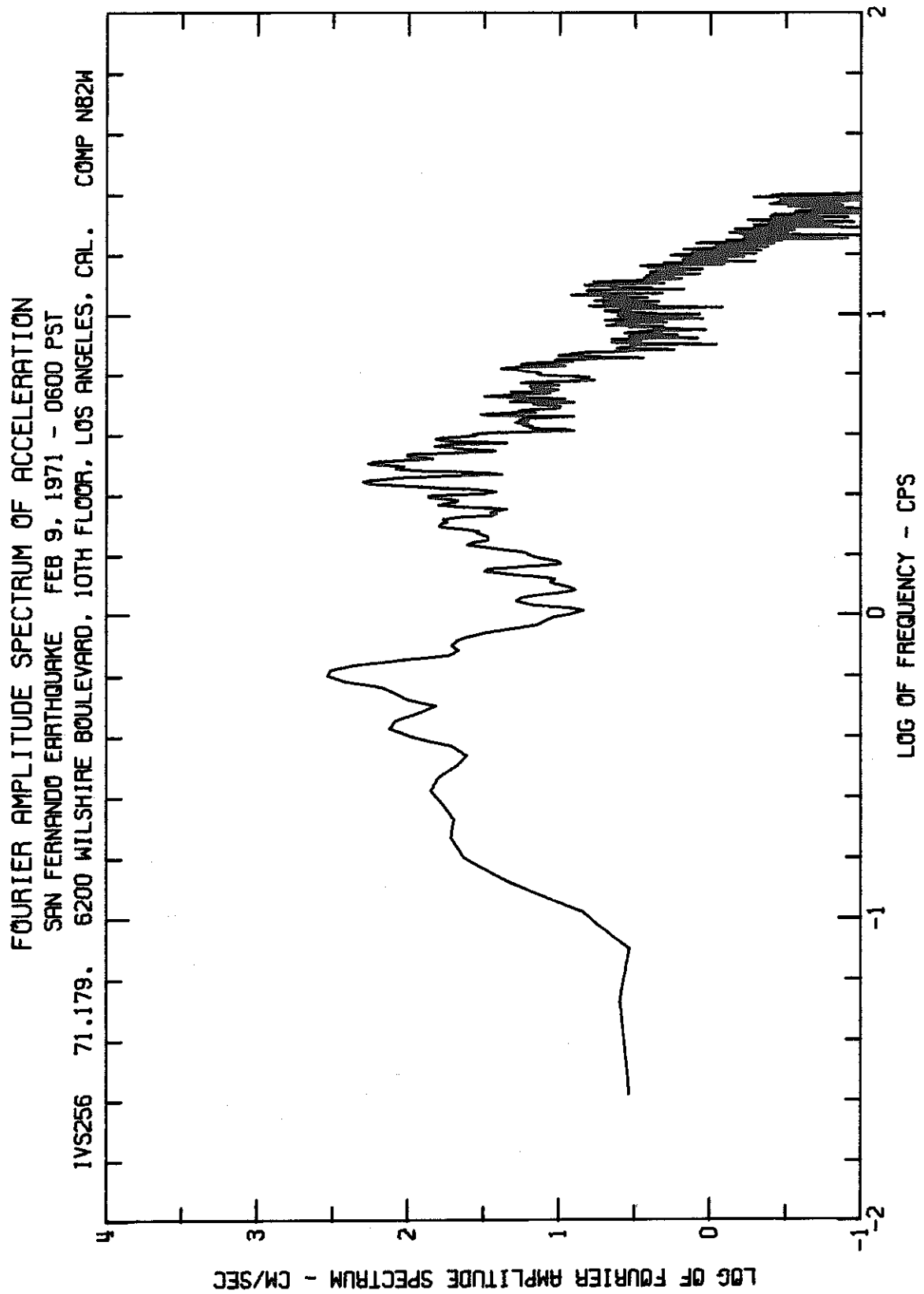


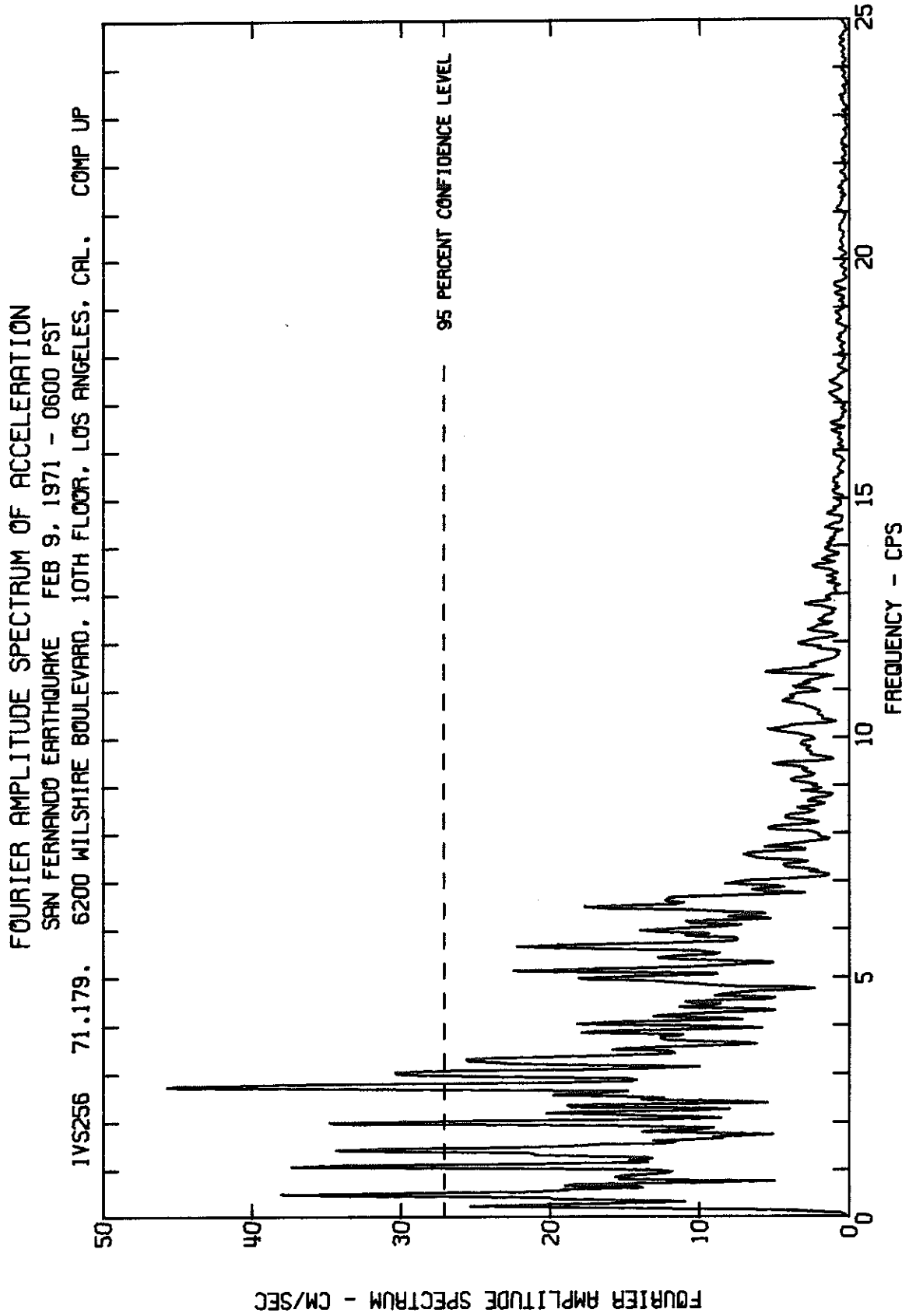
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

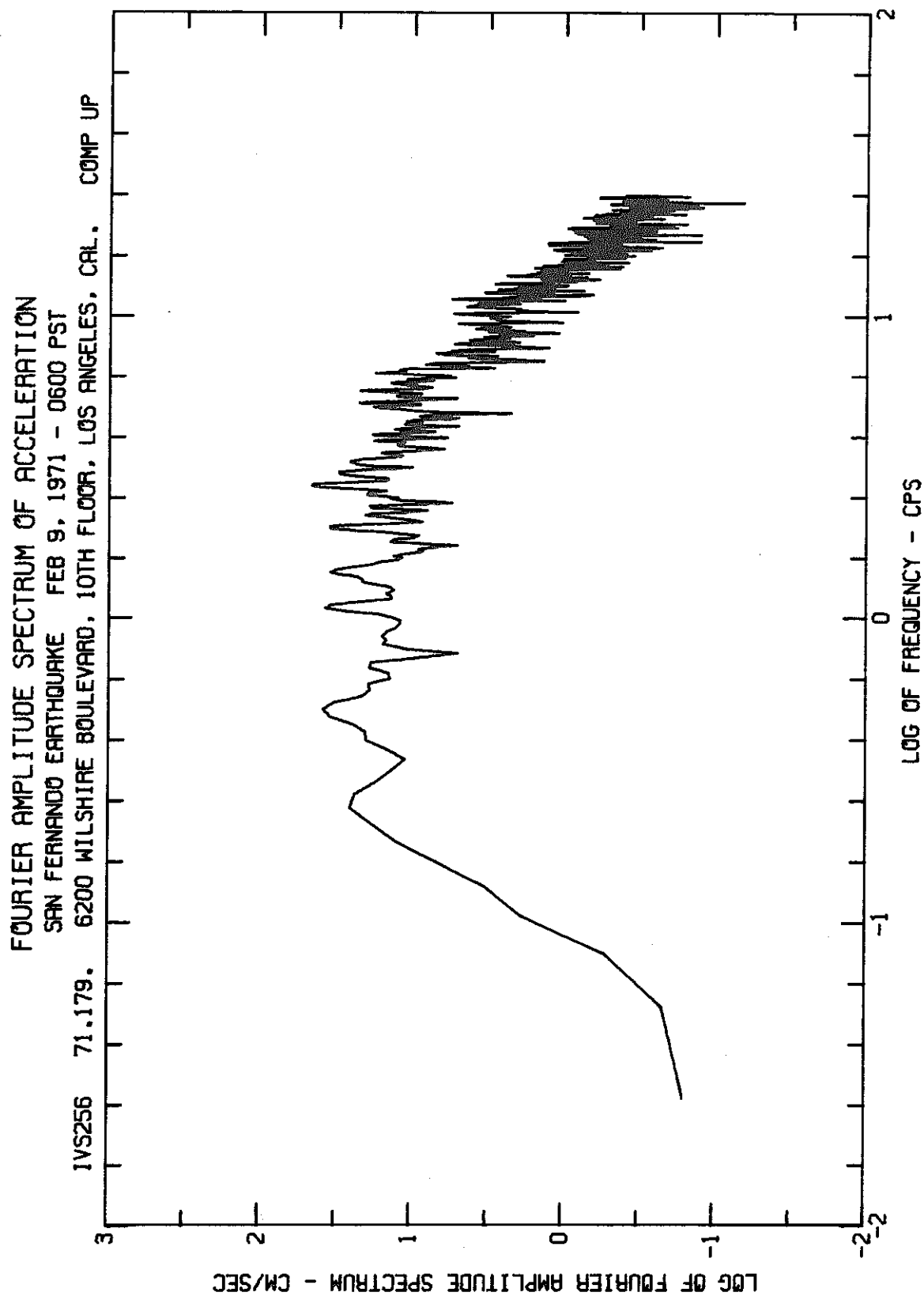
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

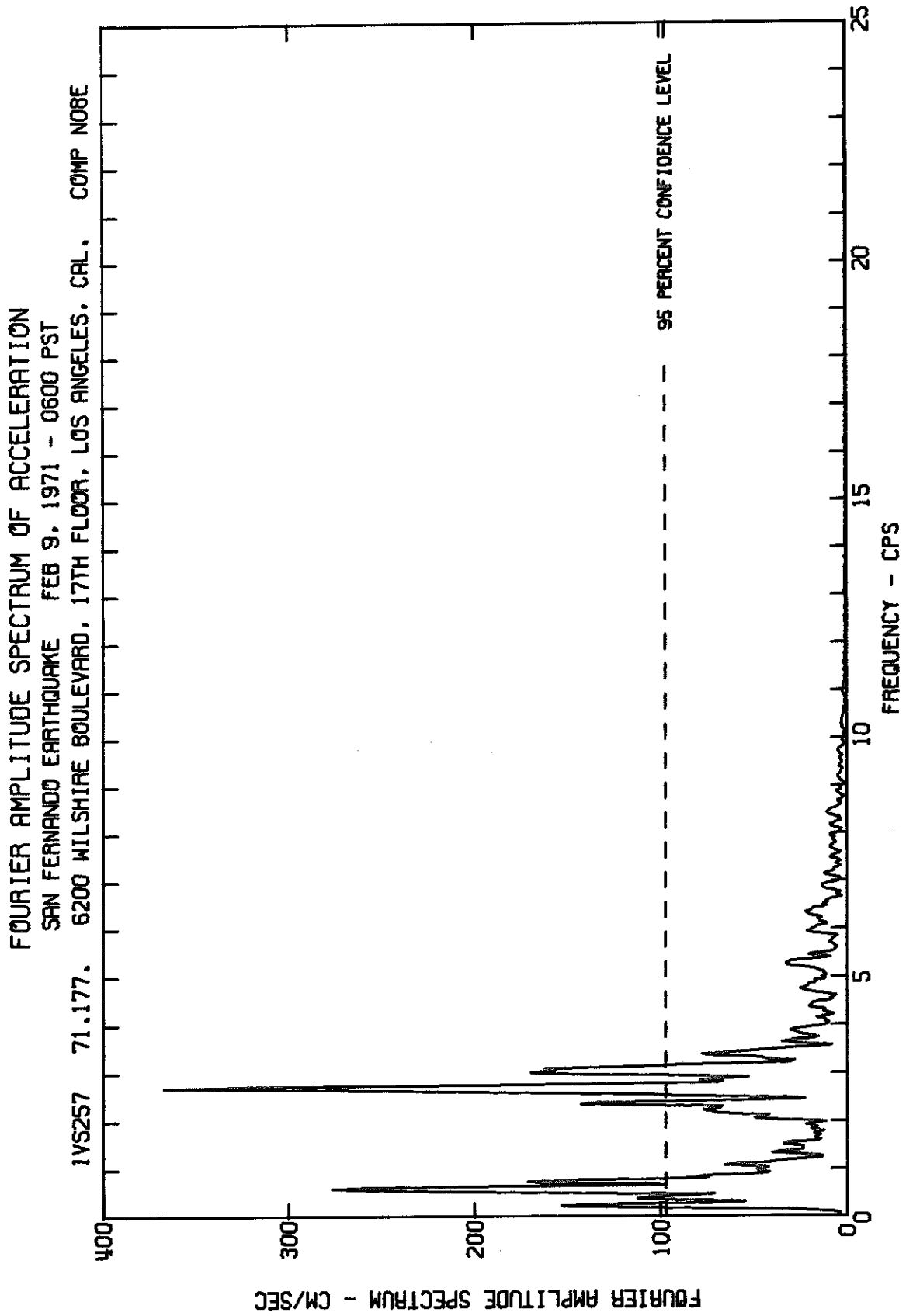
1VS256 71.179. 6200 WILSHIRE BOULEVARD, 10TH FLOOR, LOS ANGELES, CAL. COMP N82W

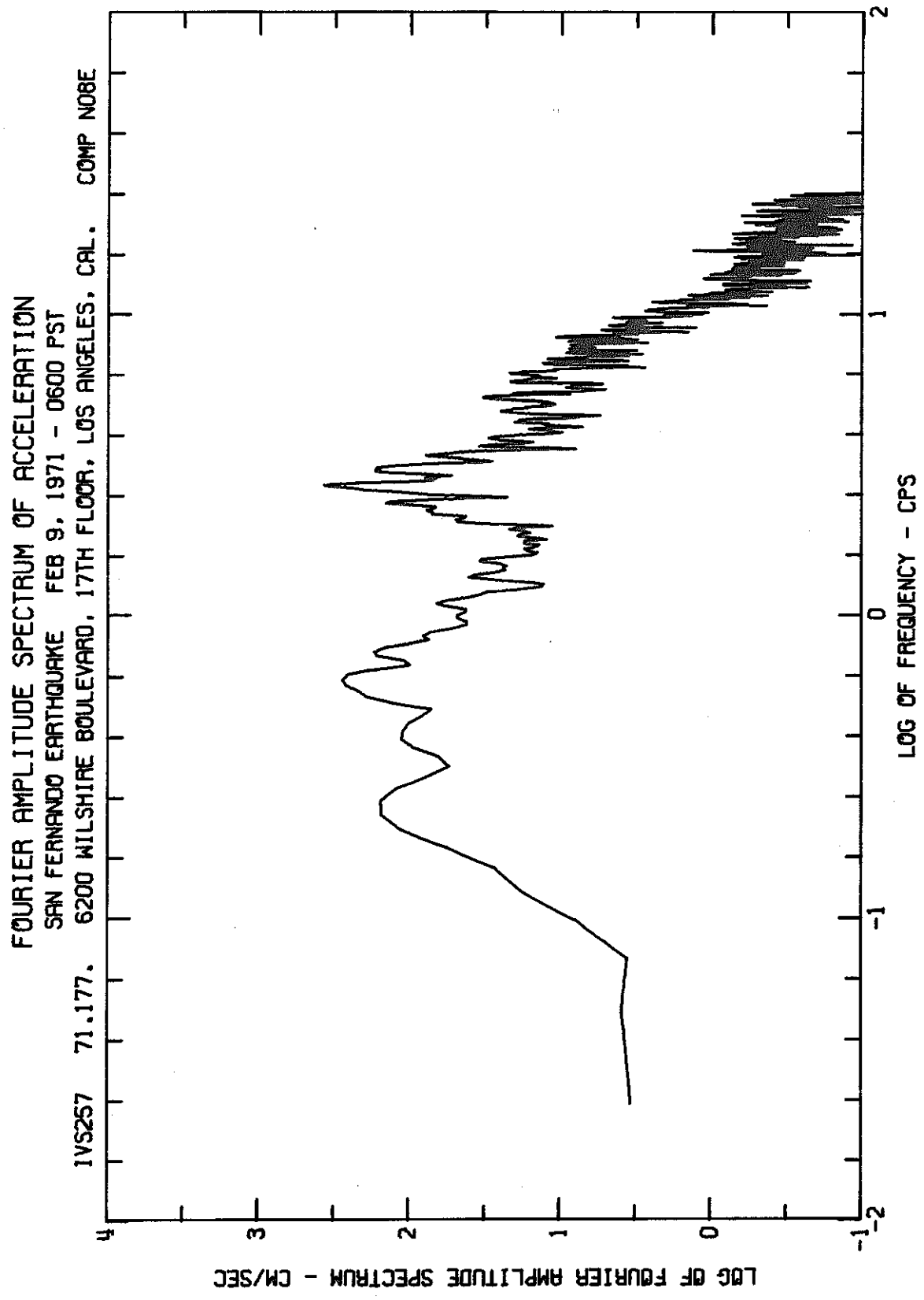


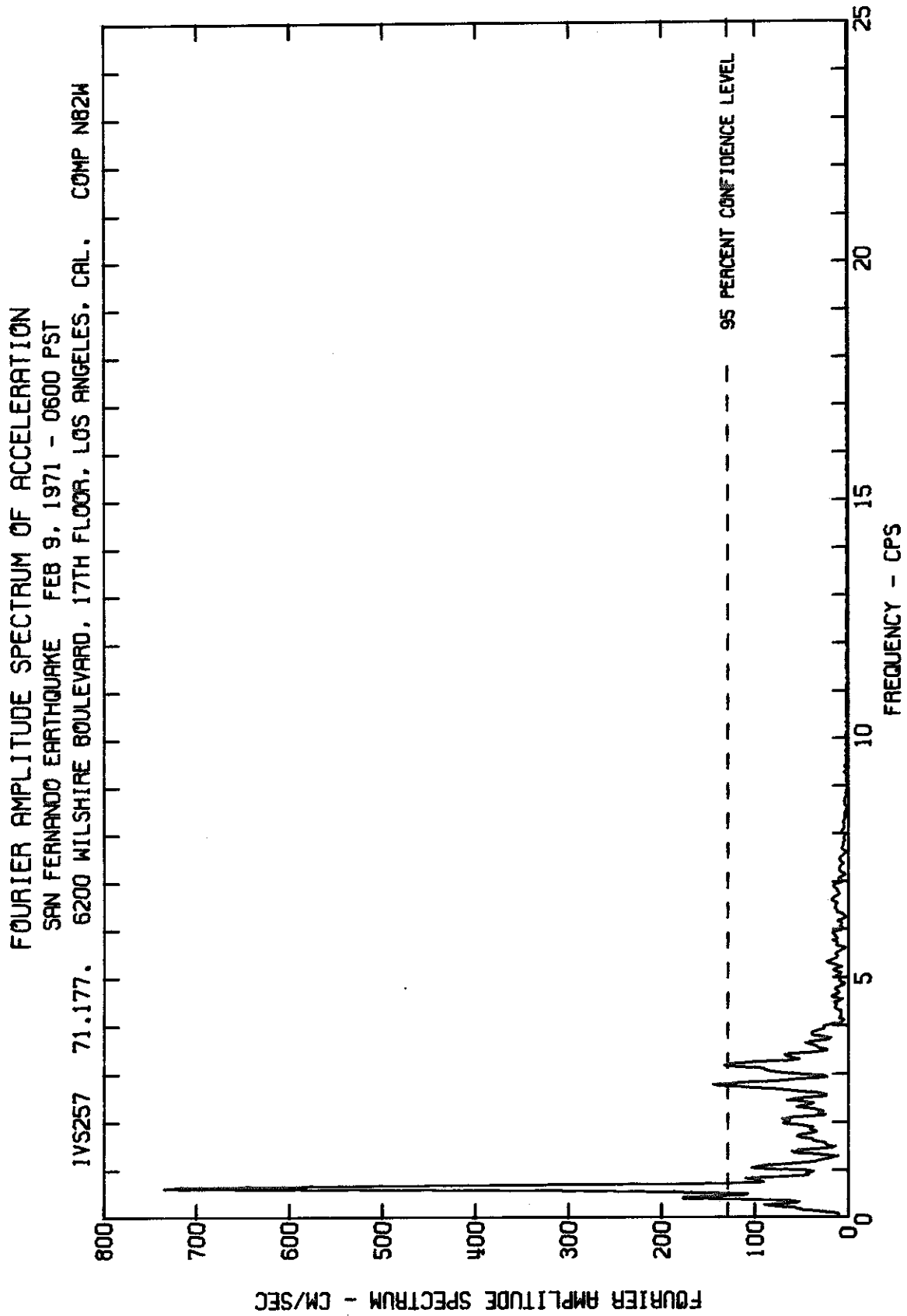


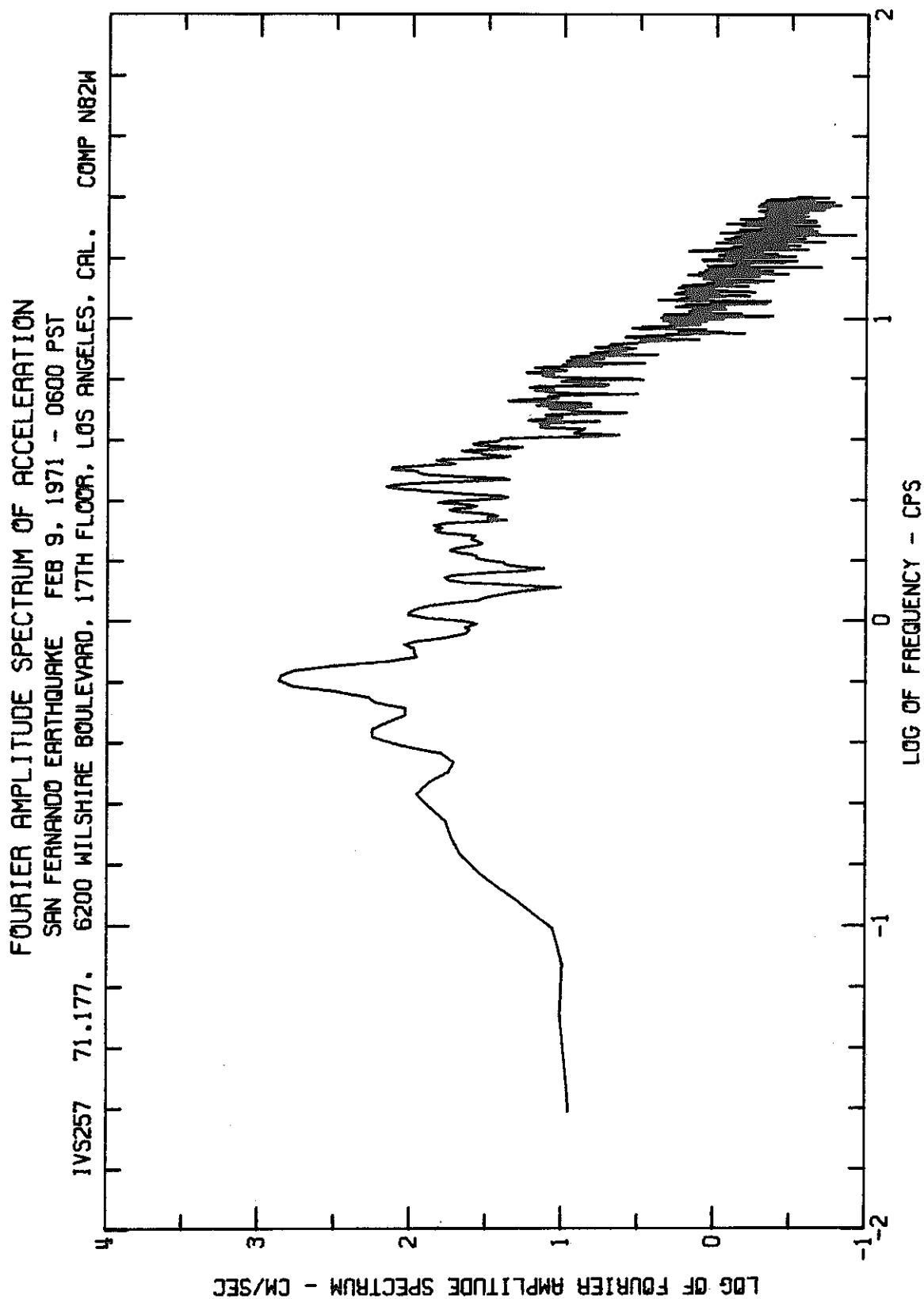


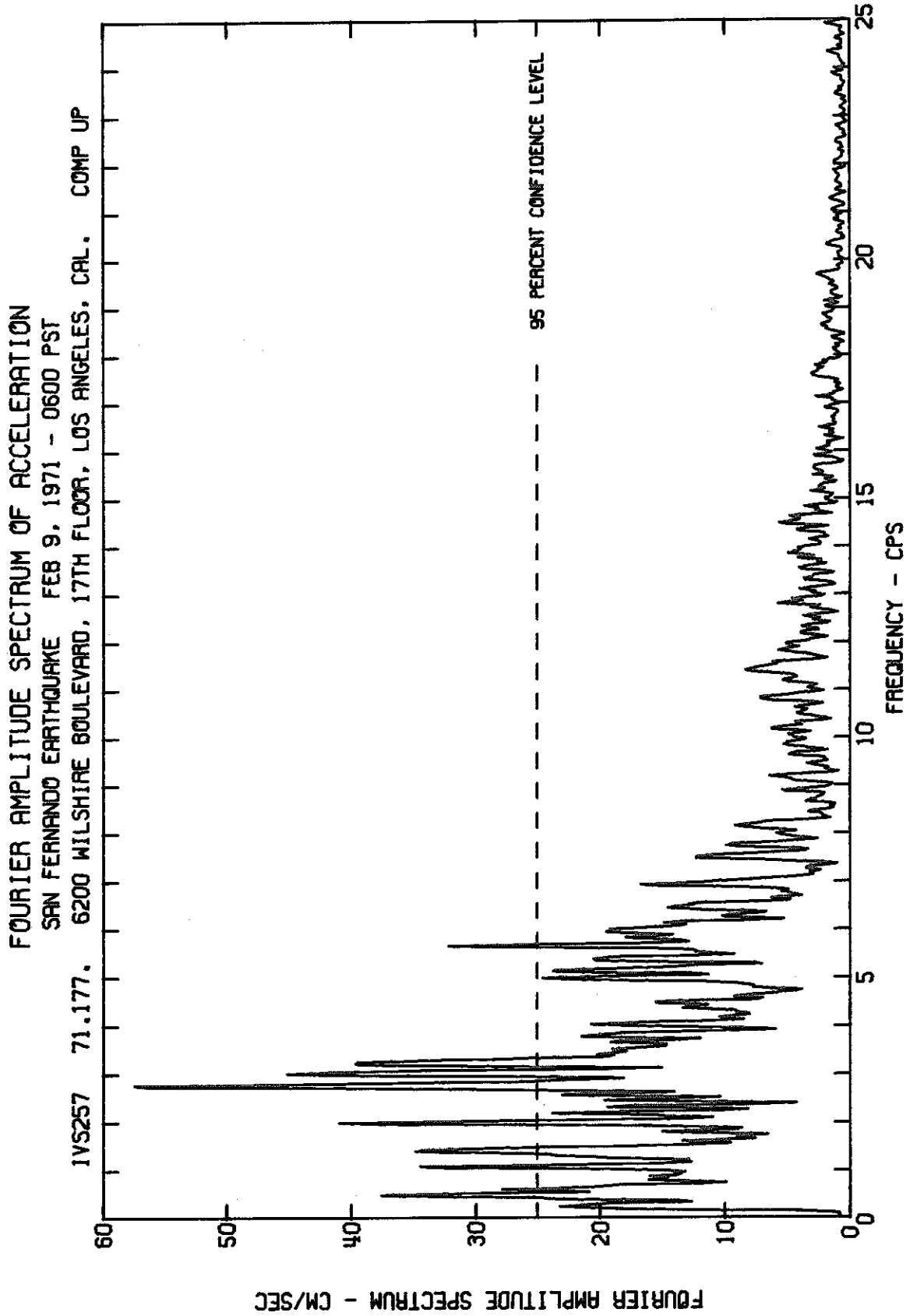


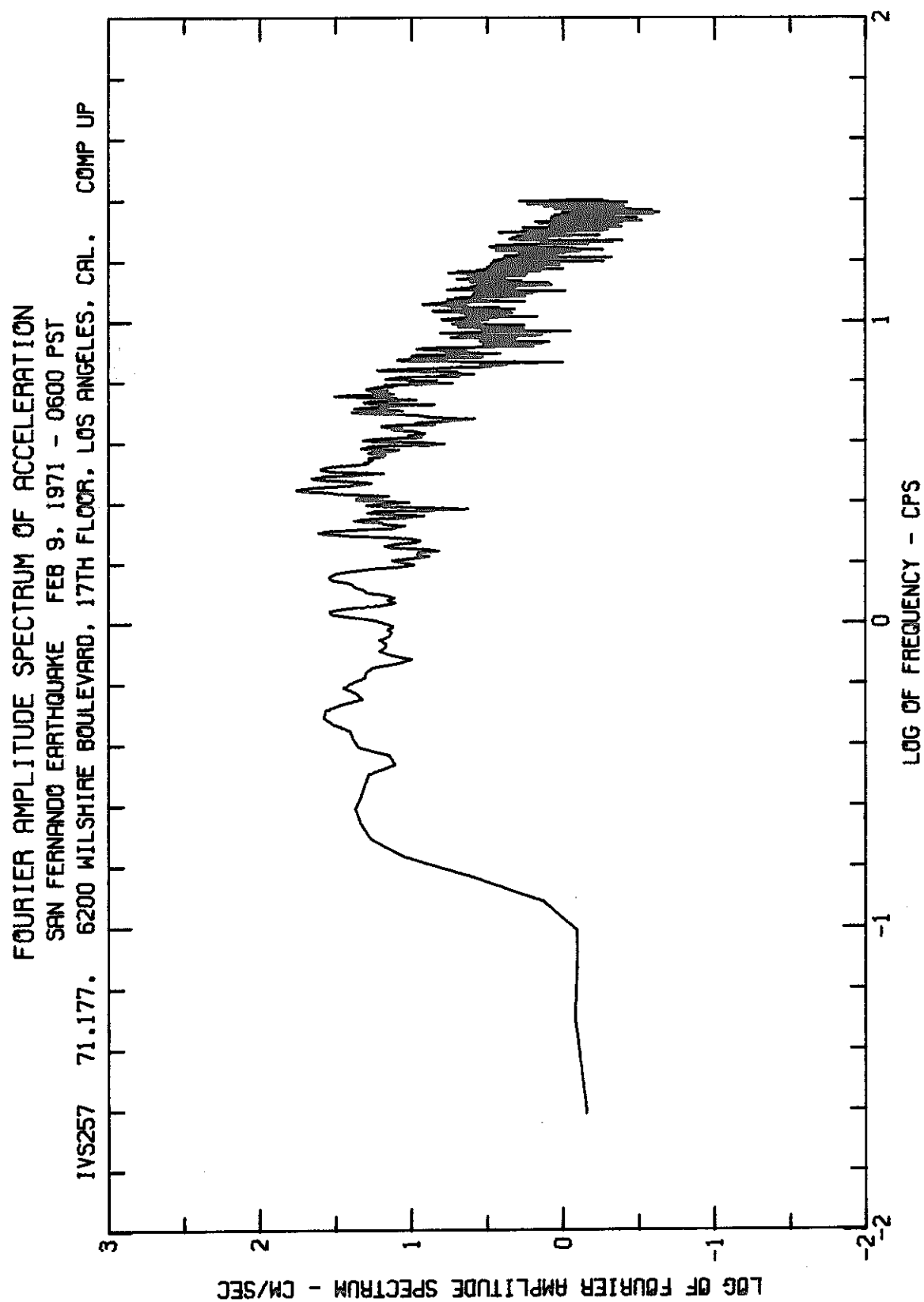


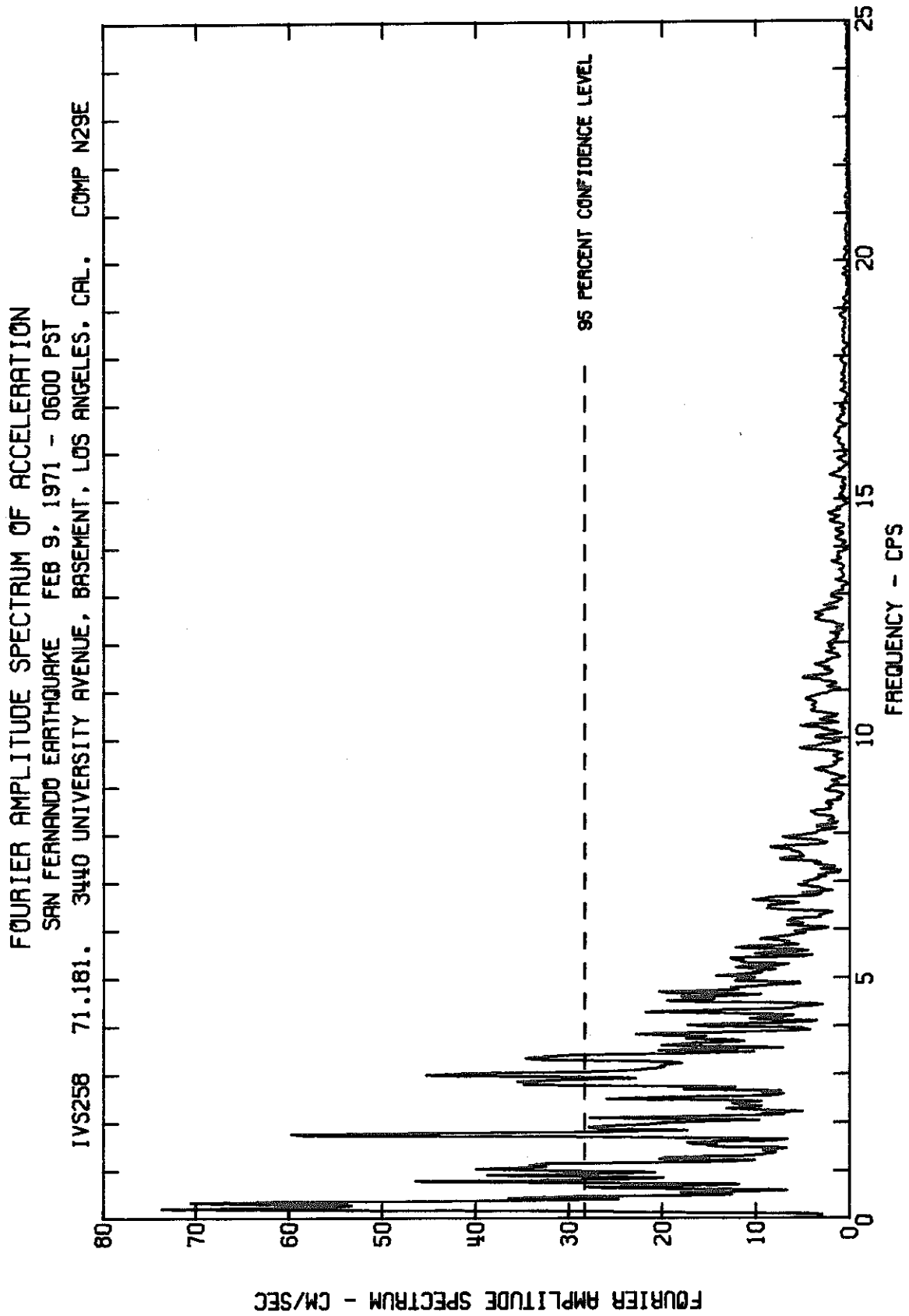


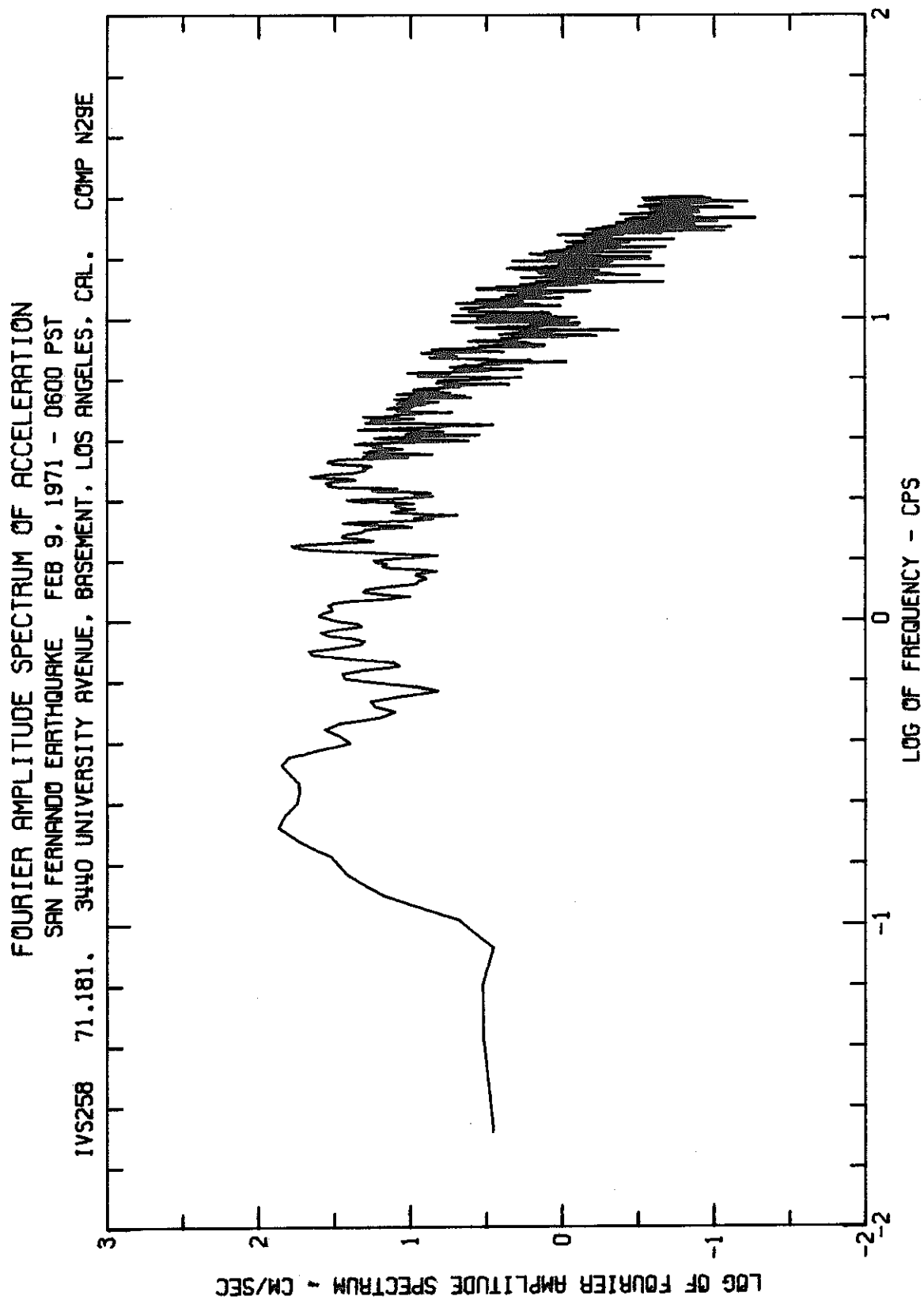


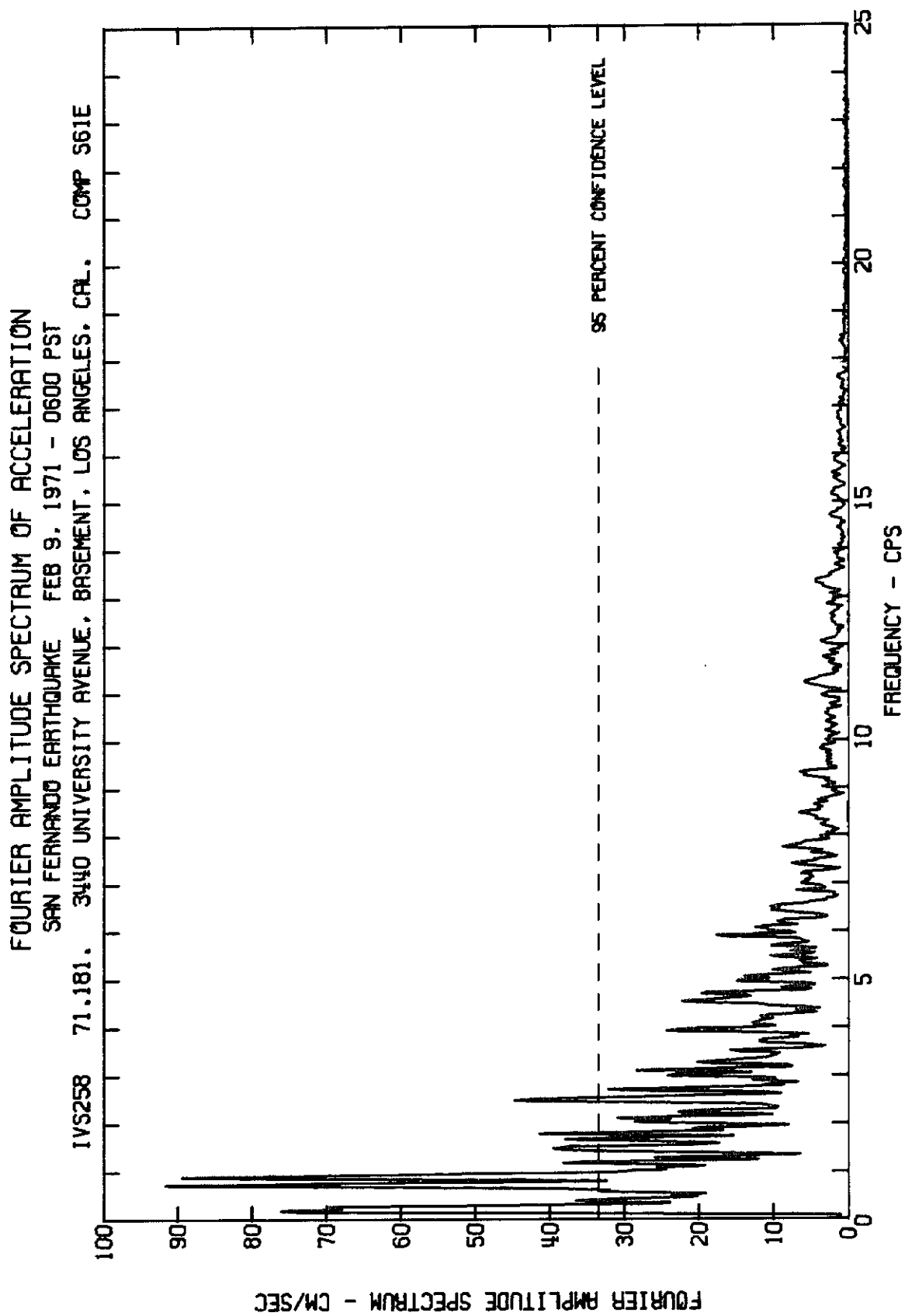


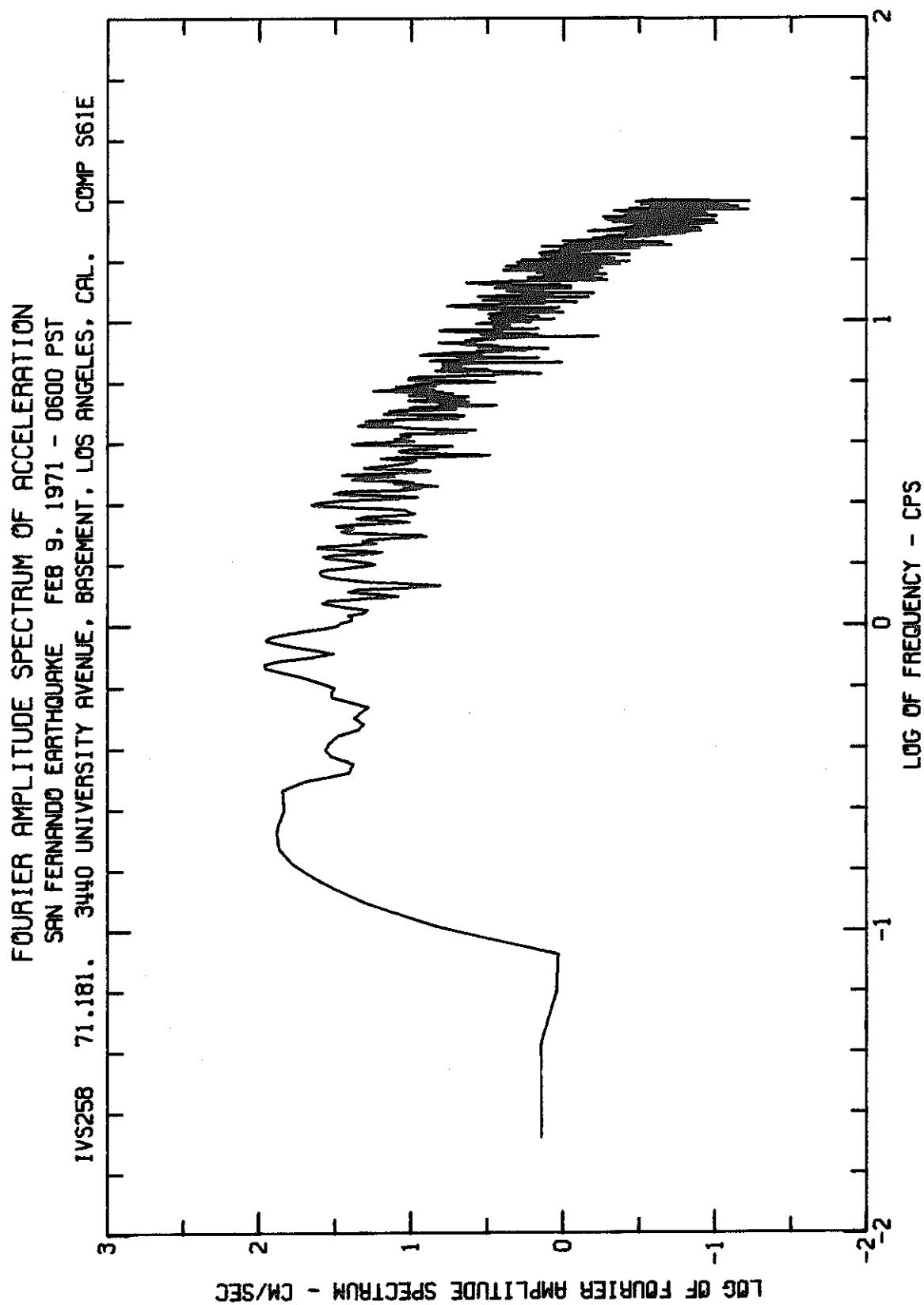


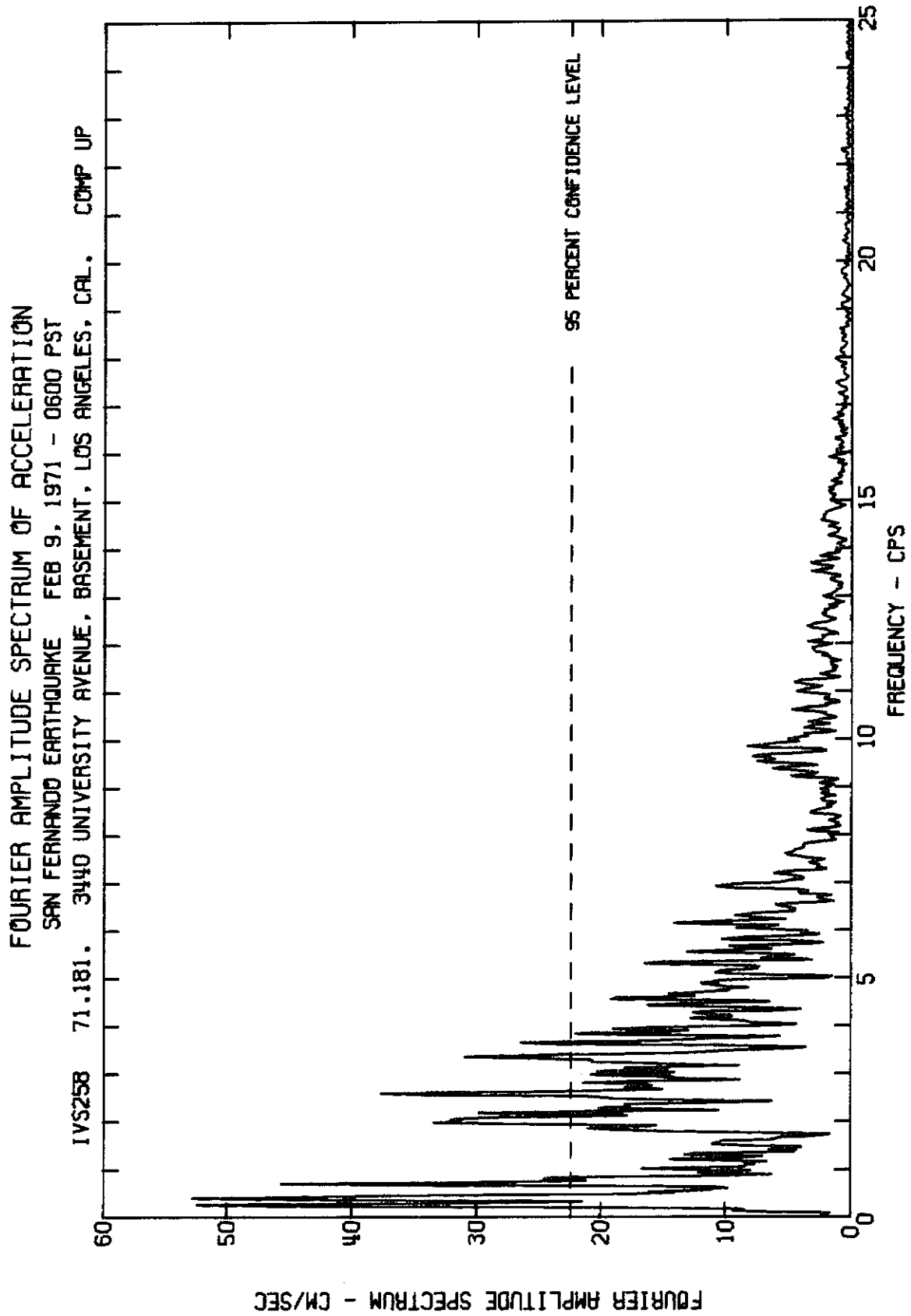


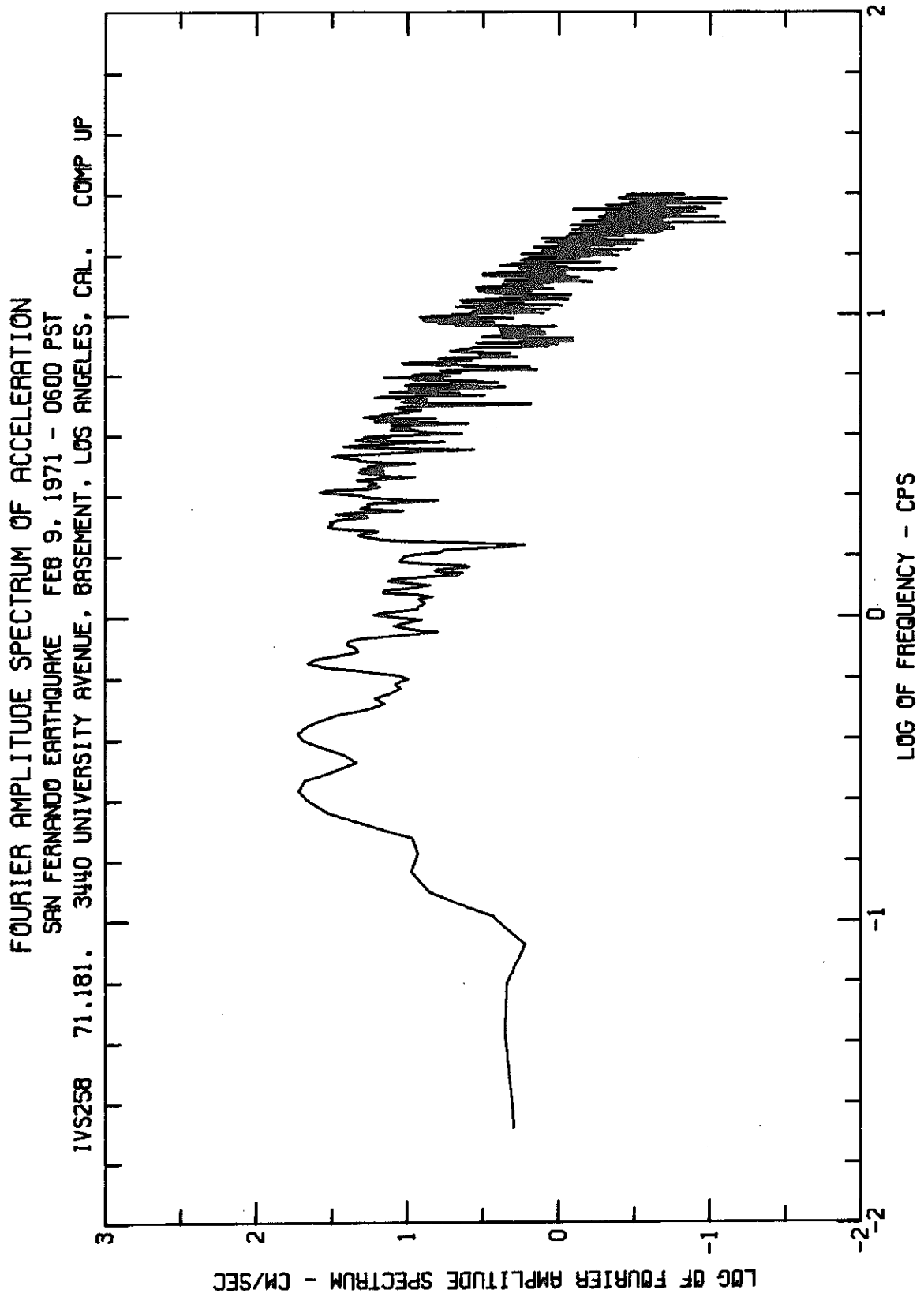


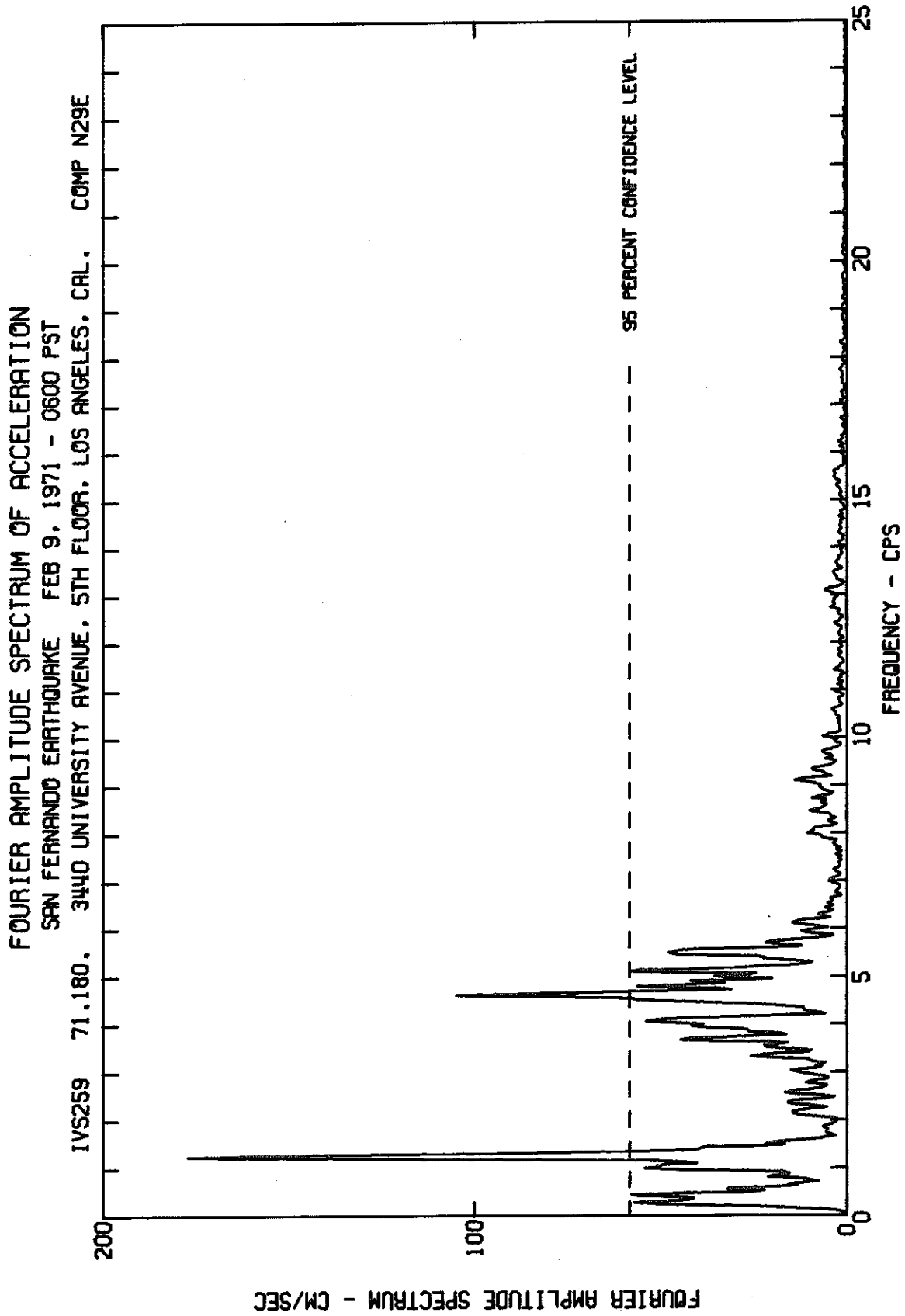


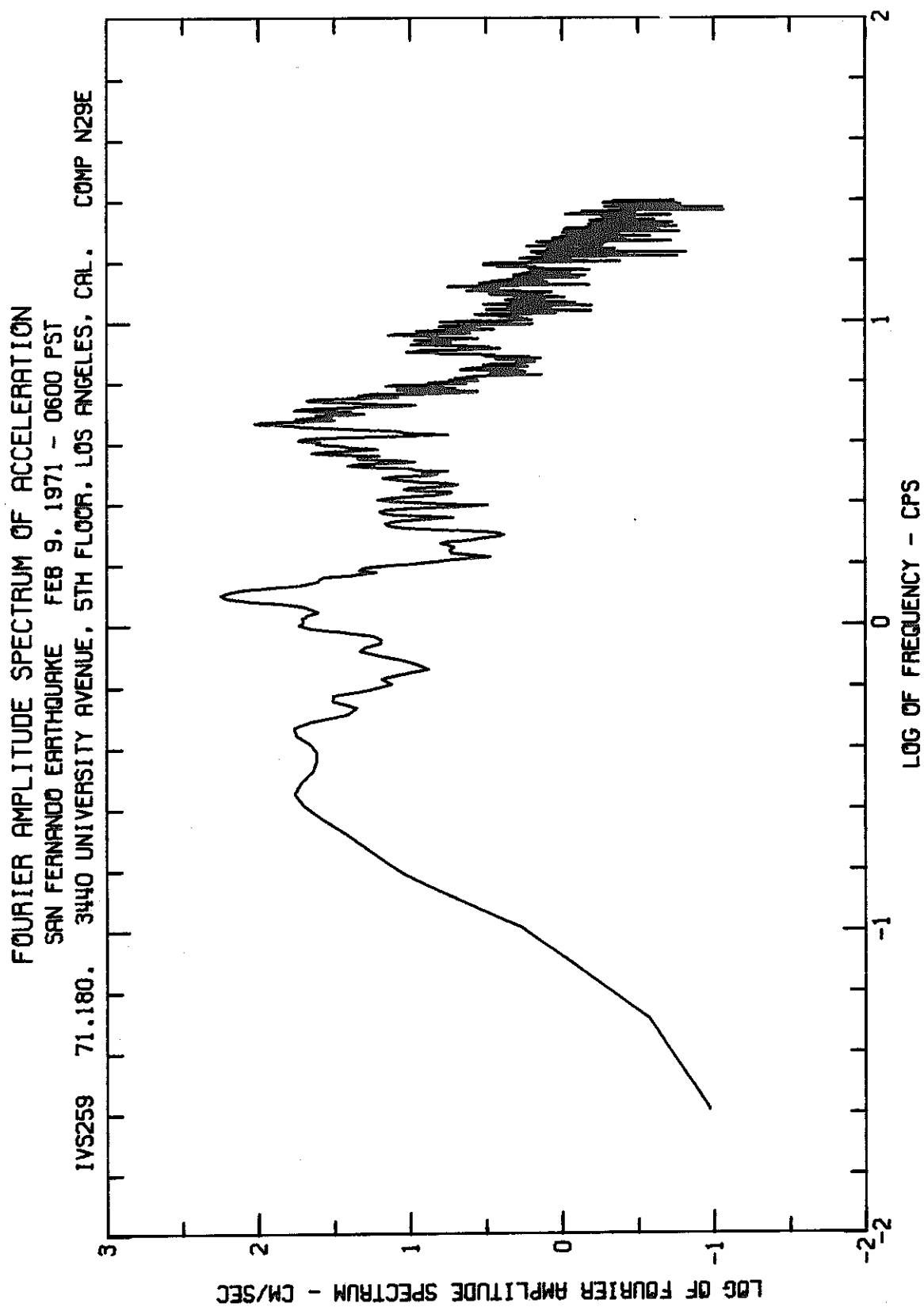


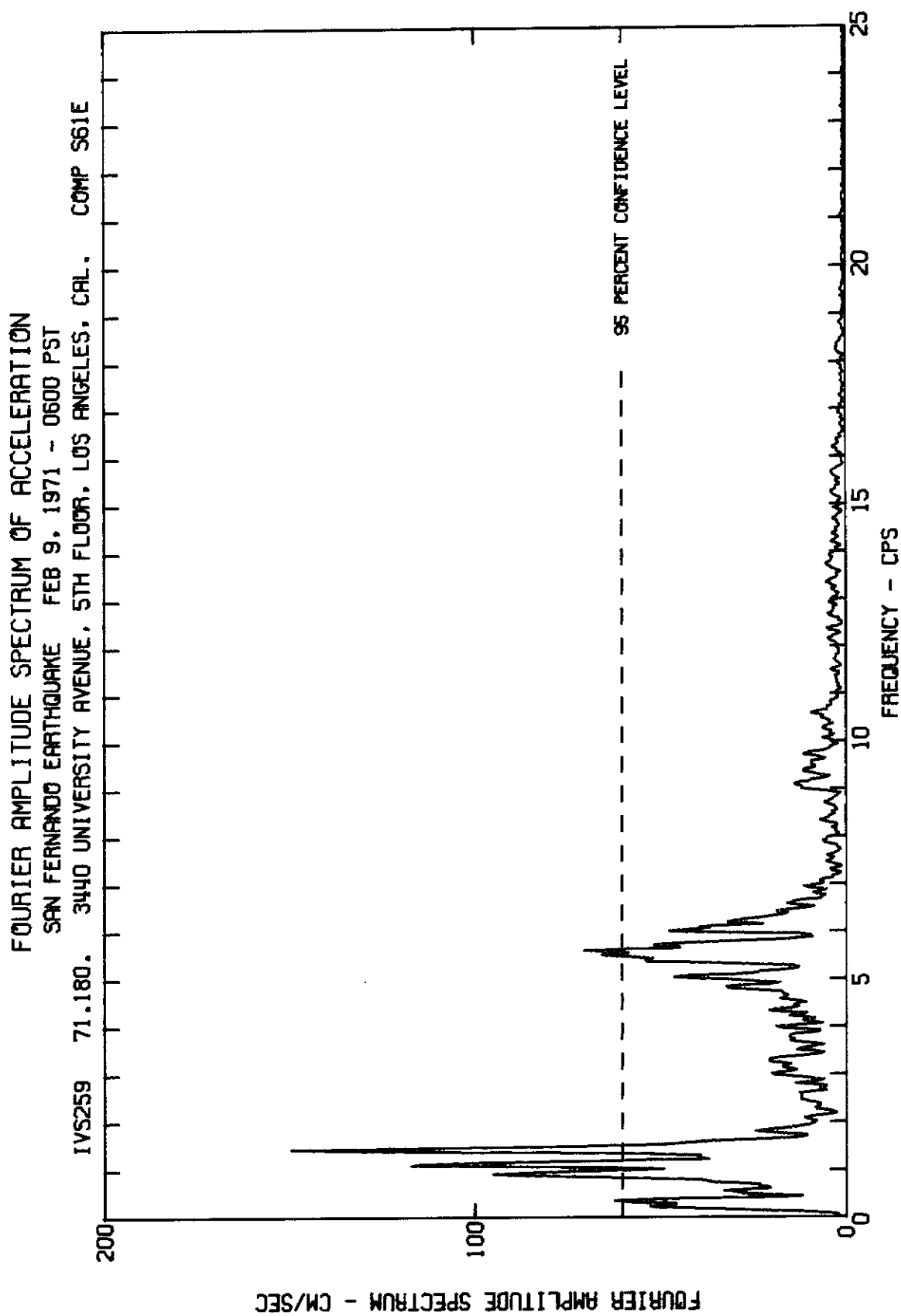


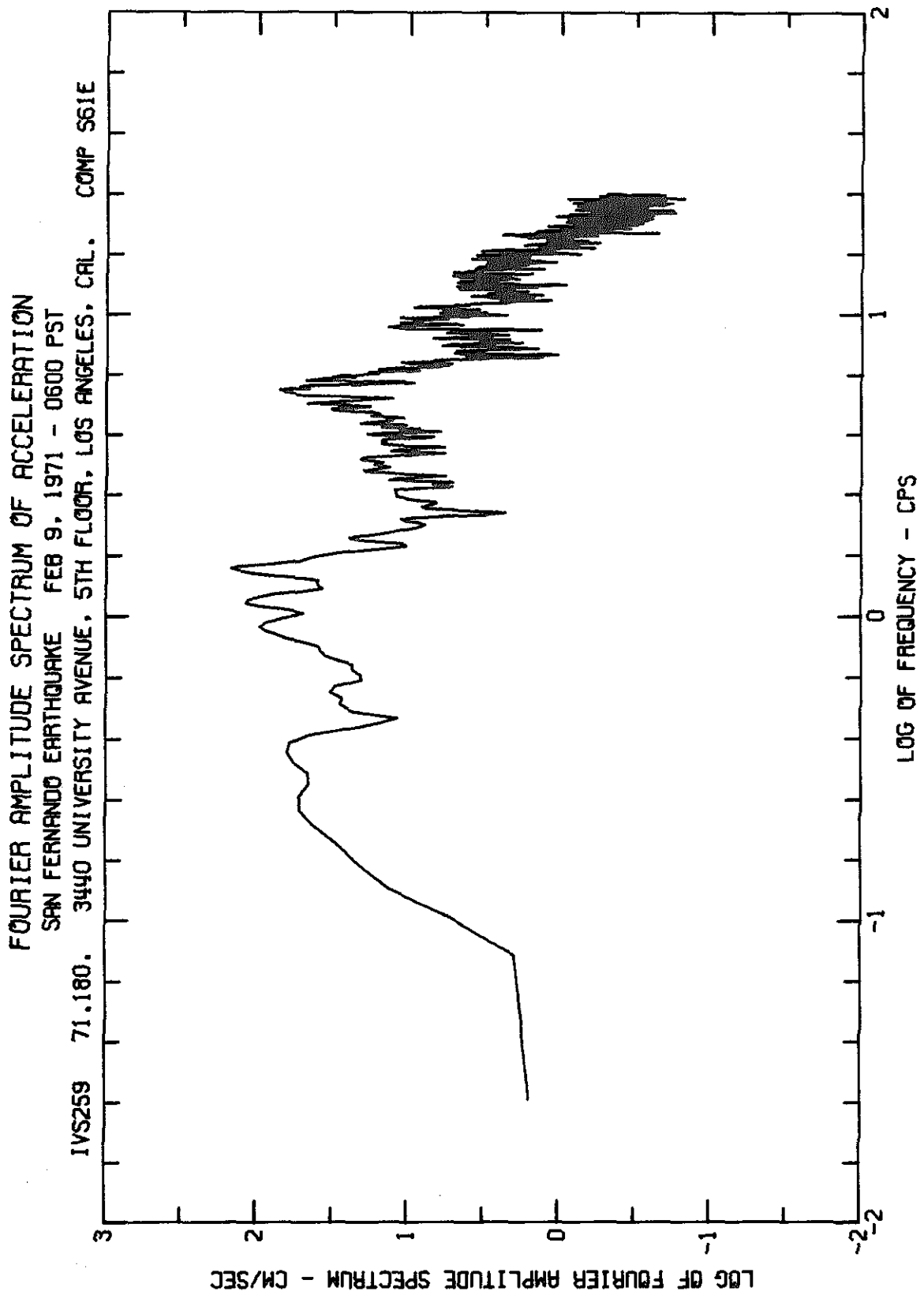


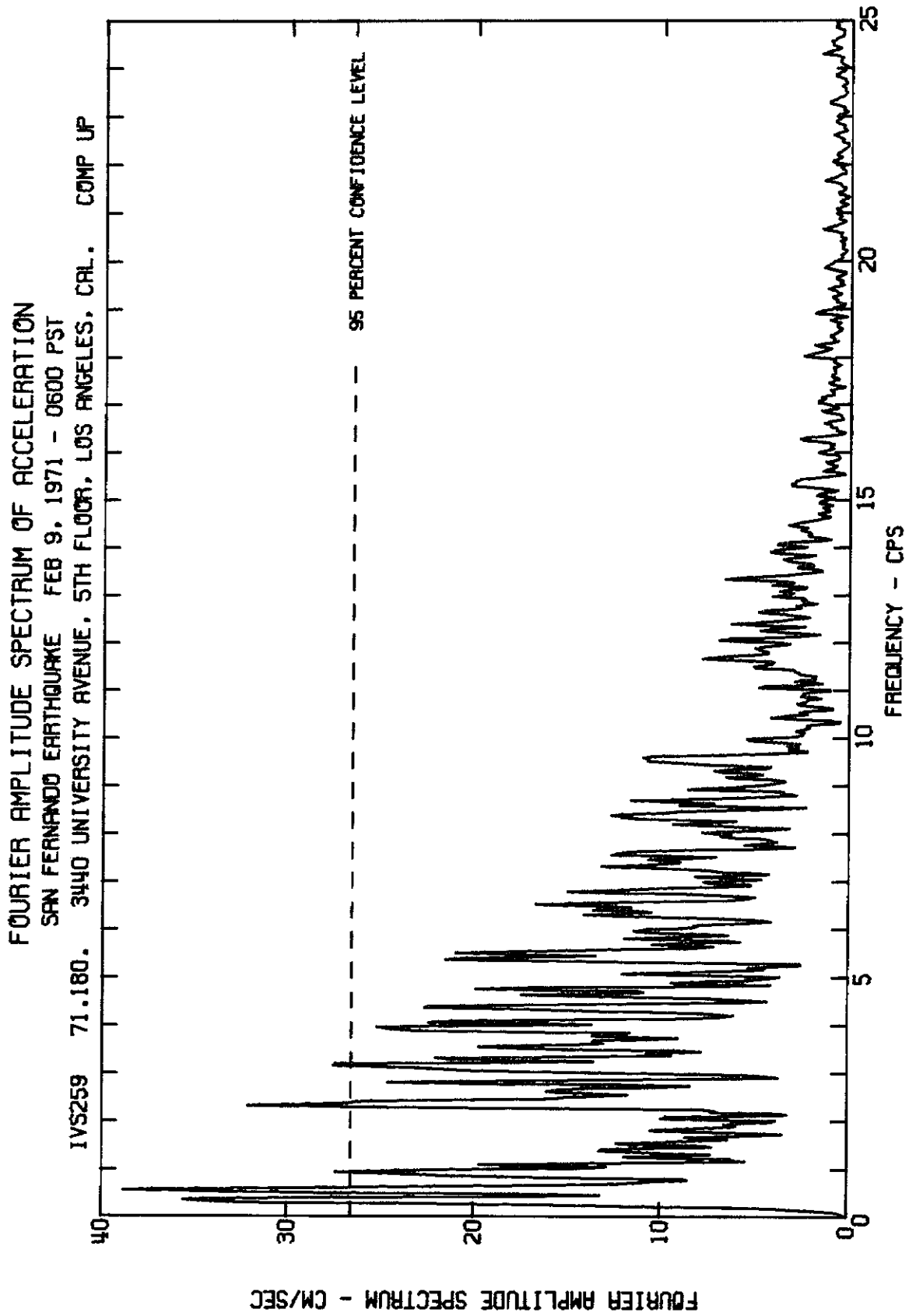


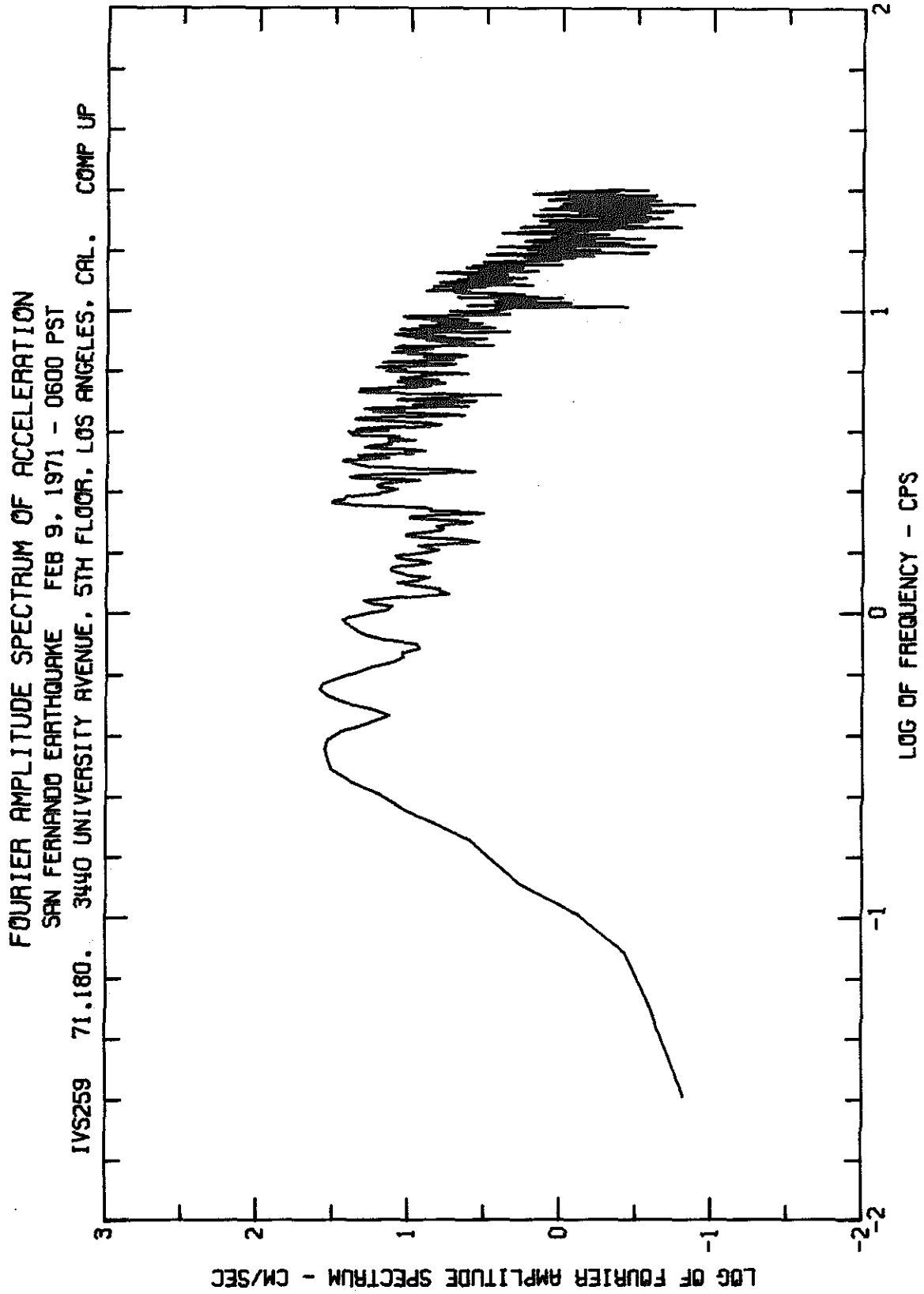


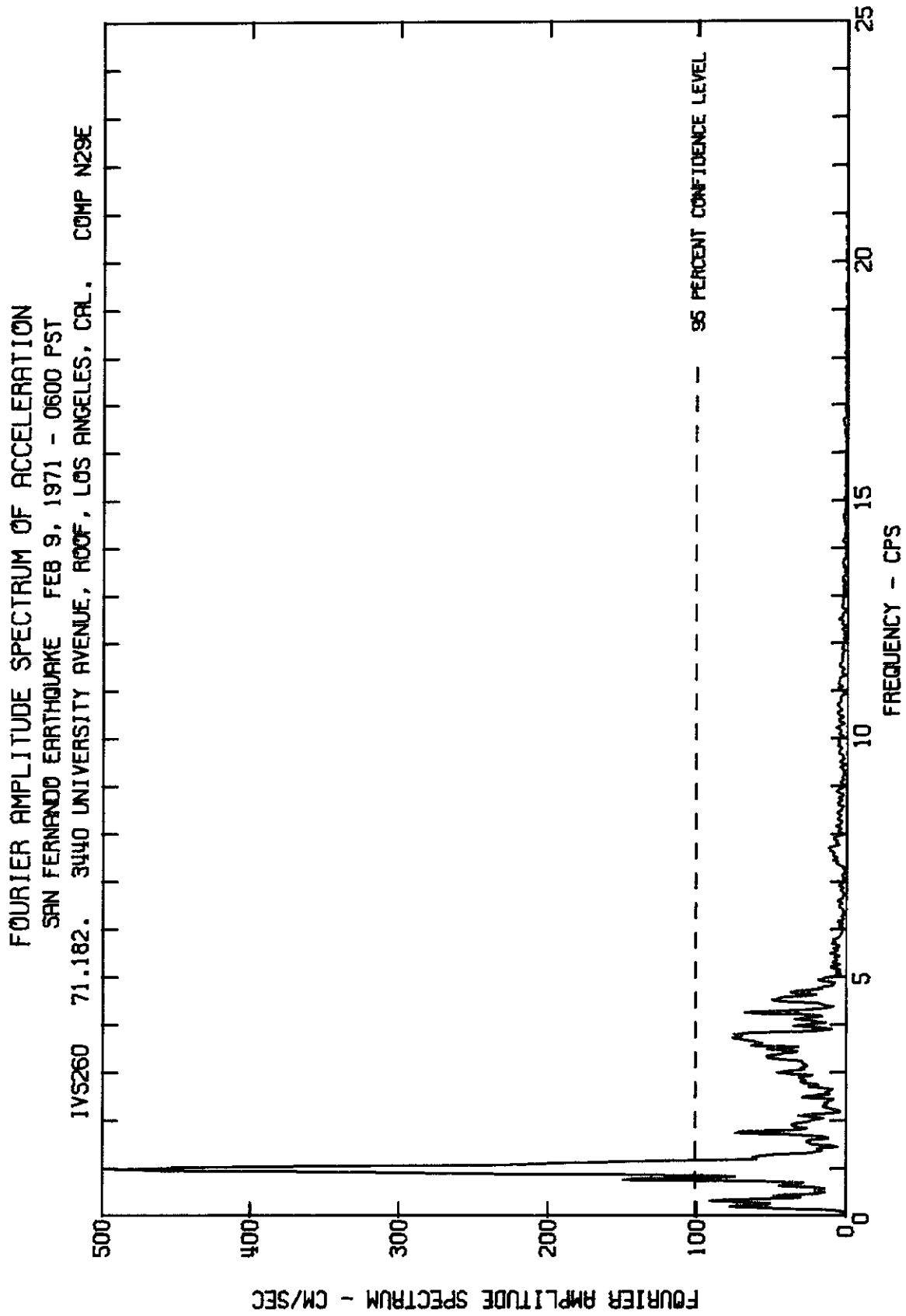


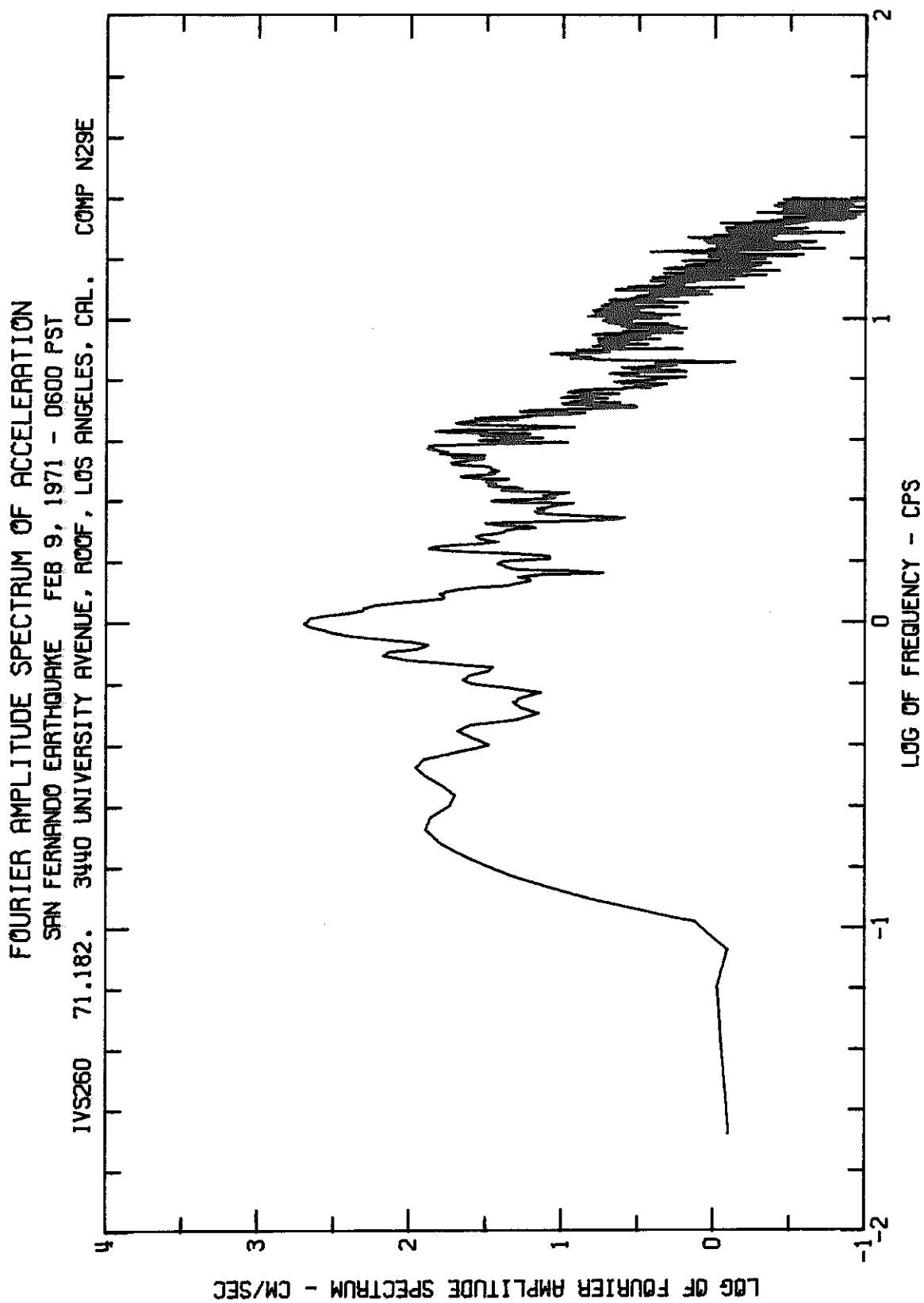


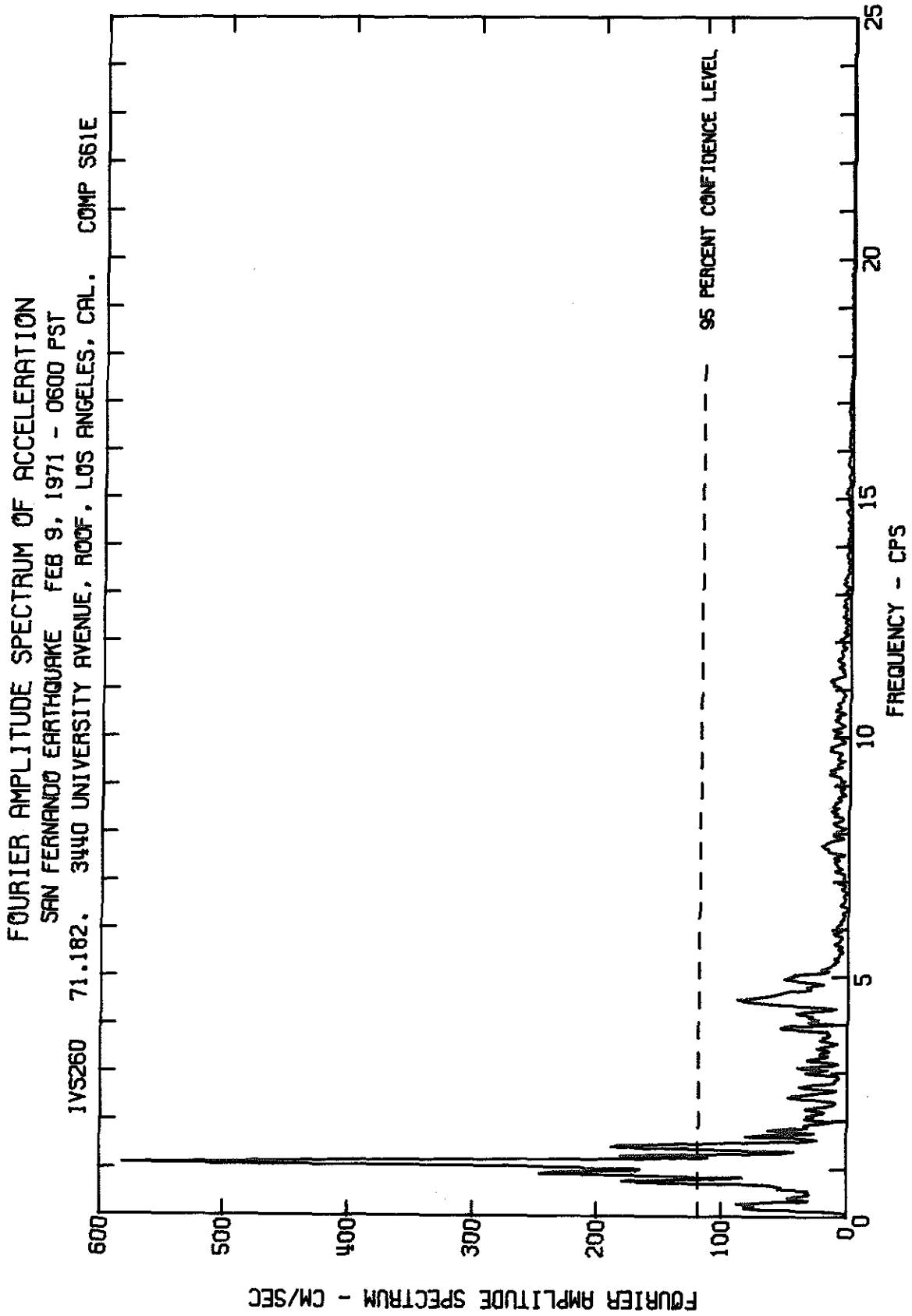


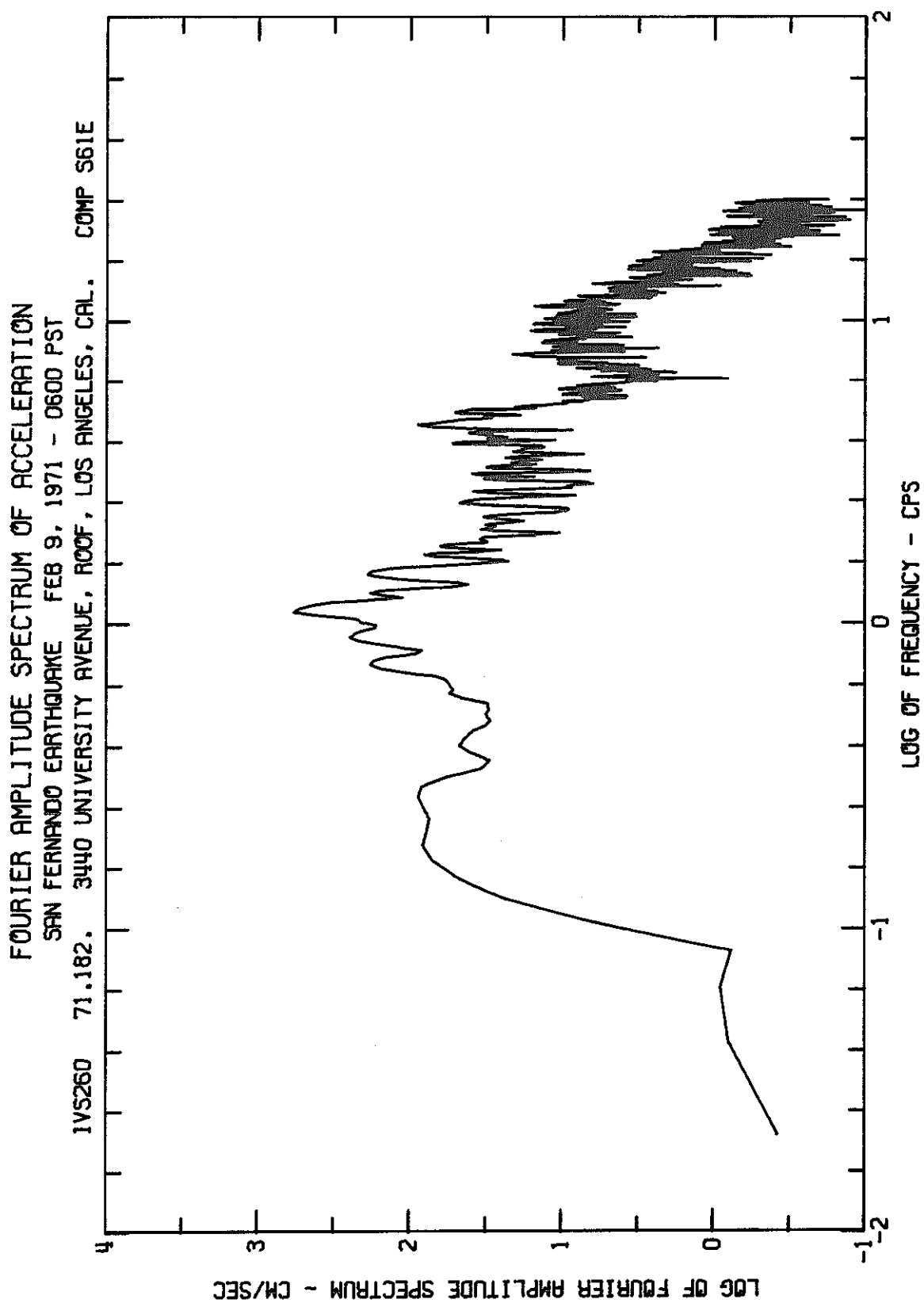




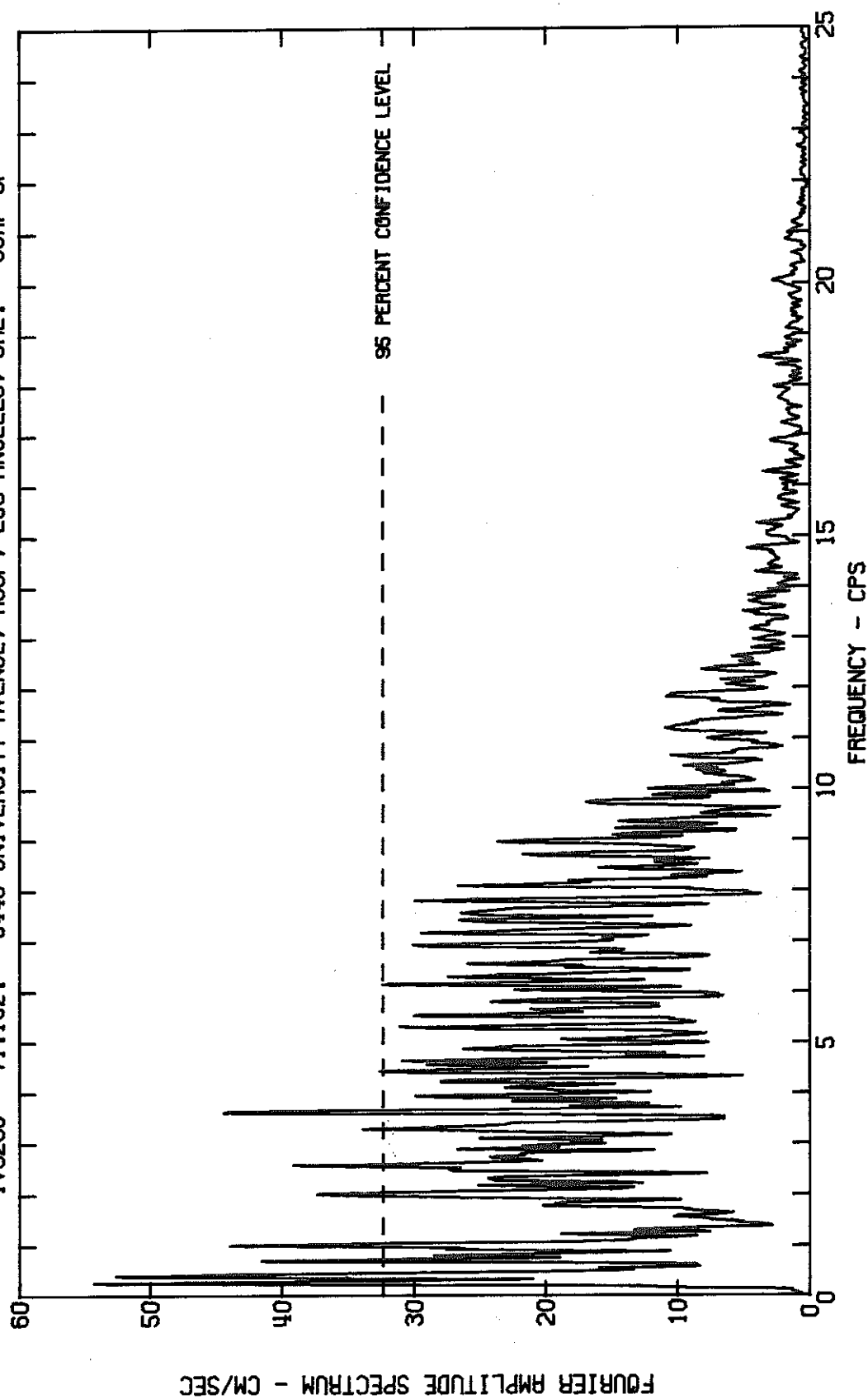


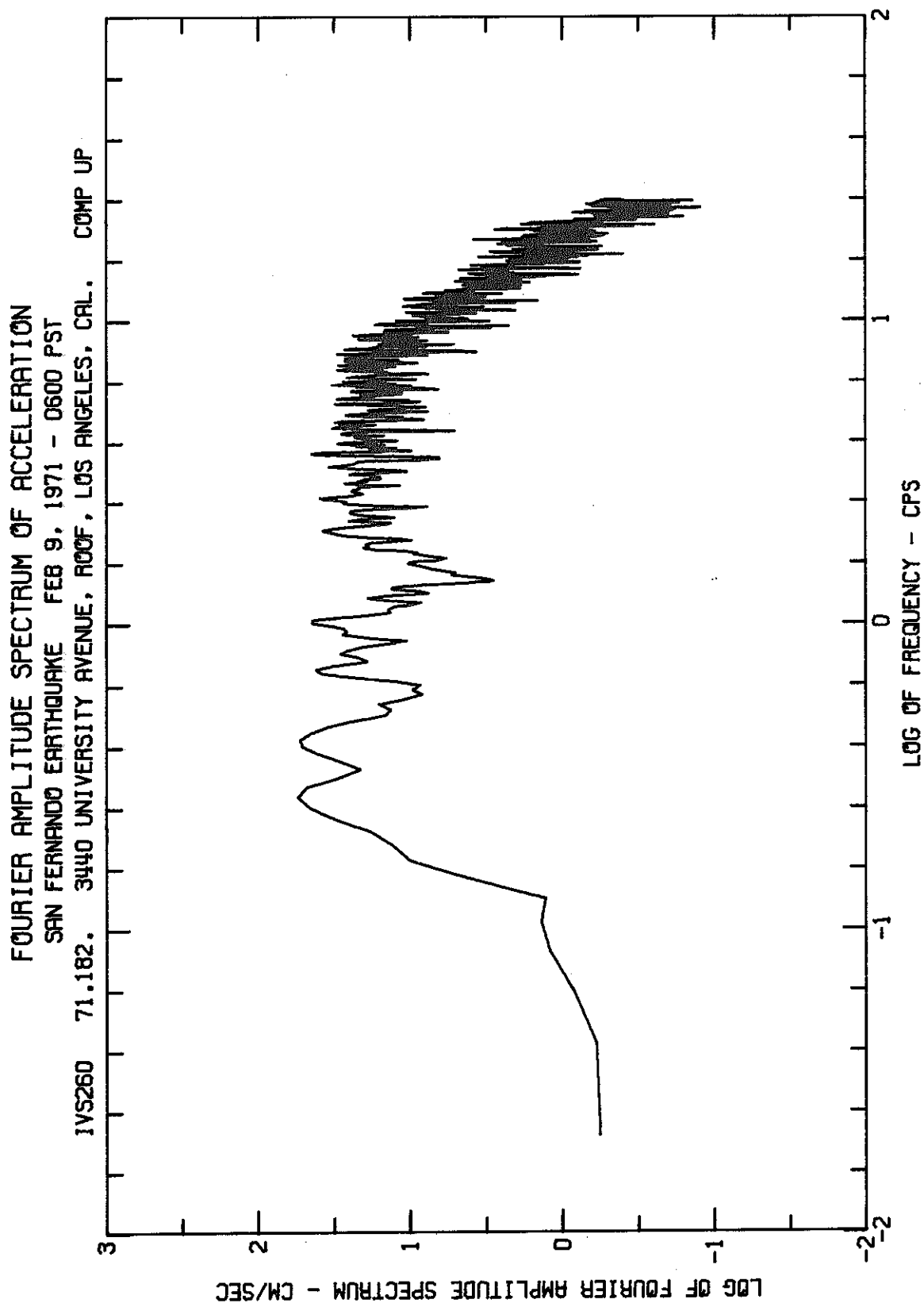


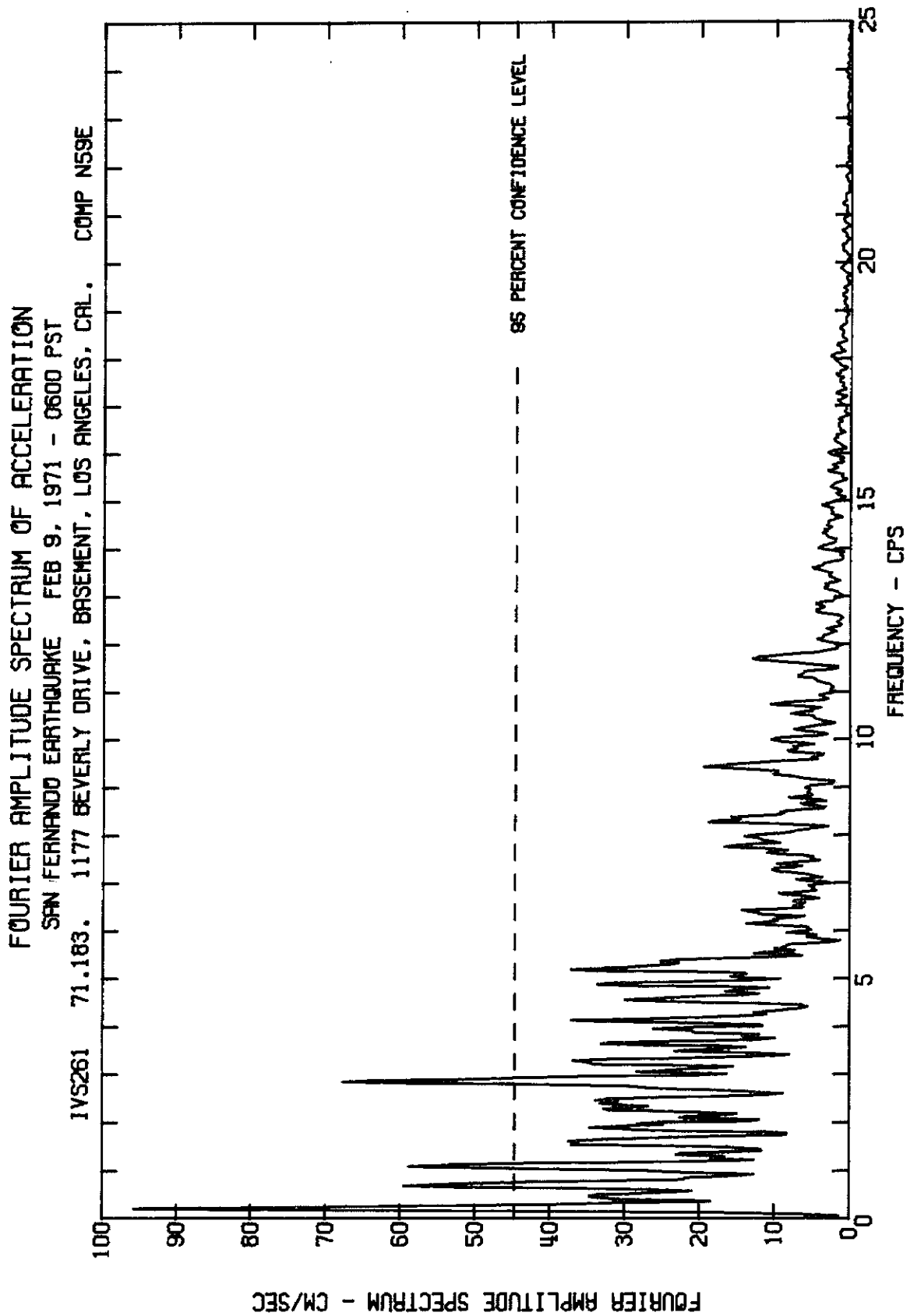


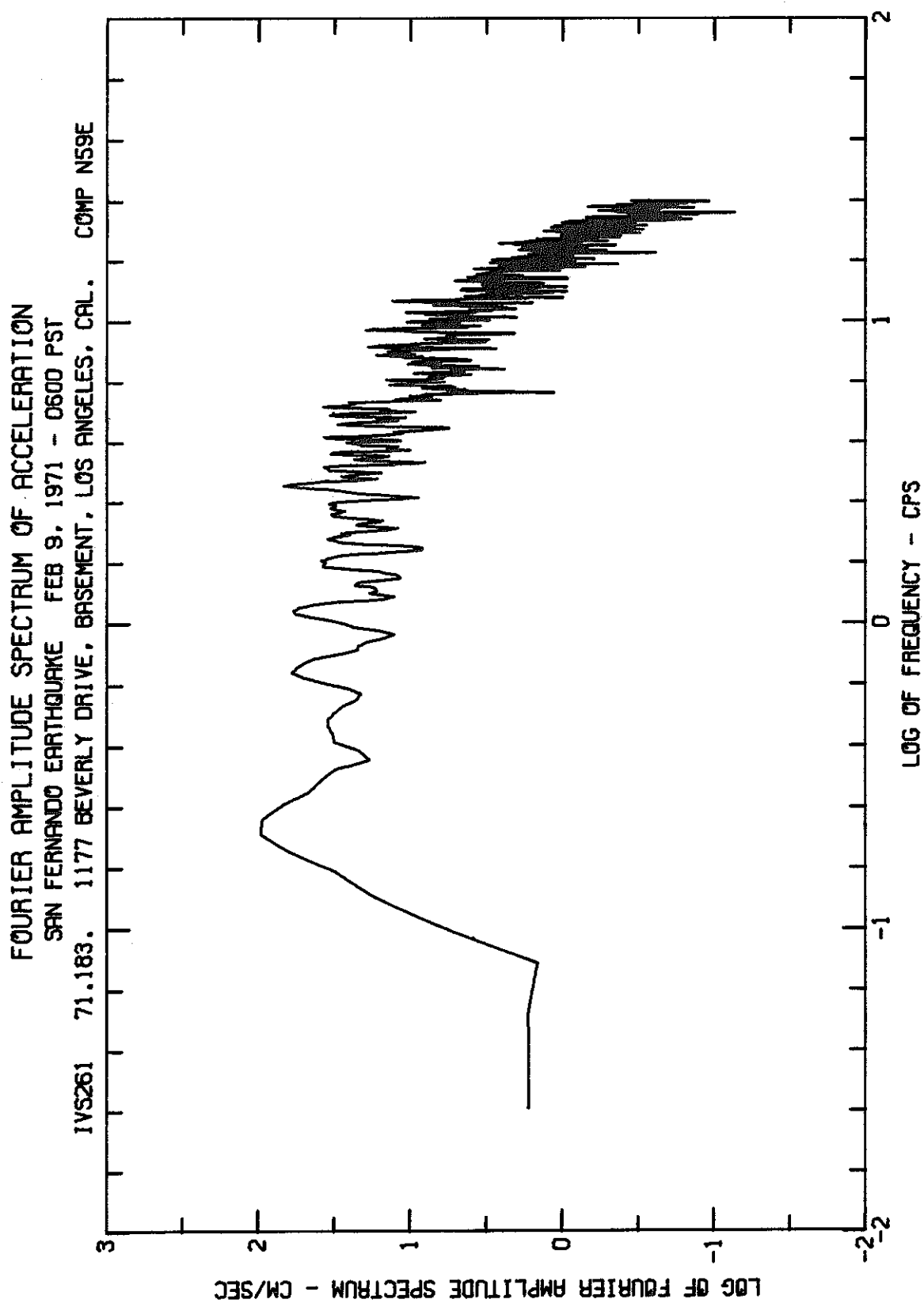


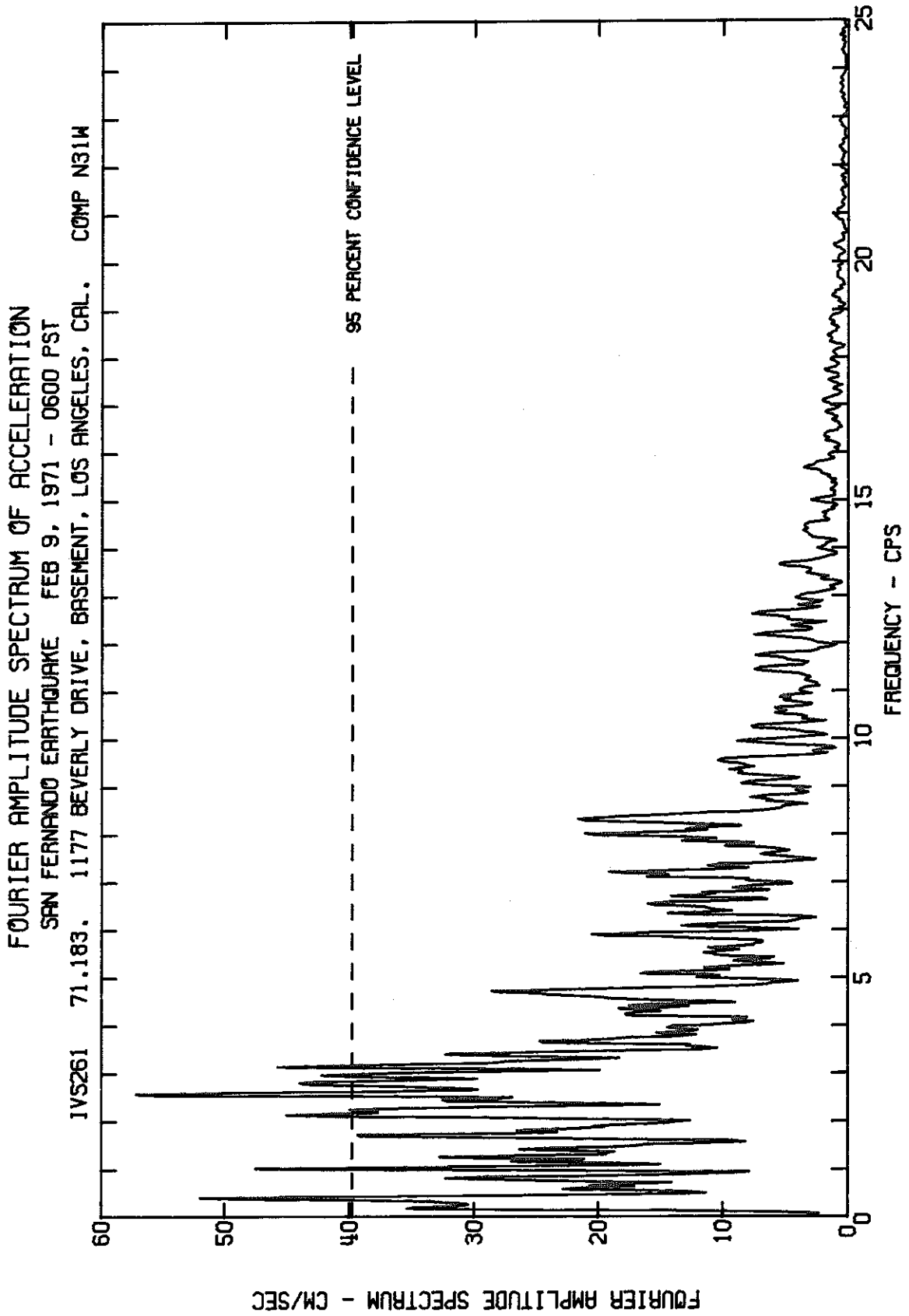
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST
1VS260 71.182. 3440 UNIVERSITY AVENUE, ROOF, LOS ANGELES, CAL. COMP UP

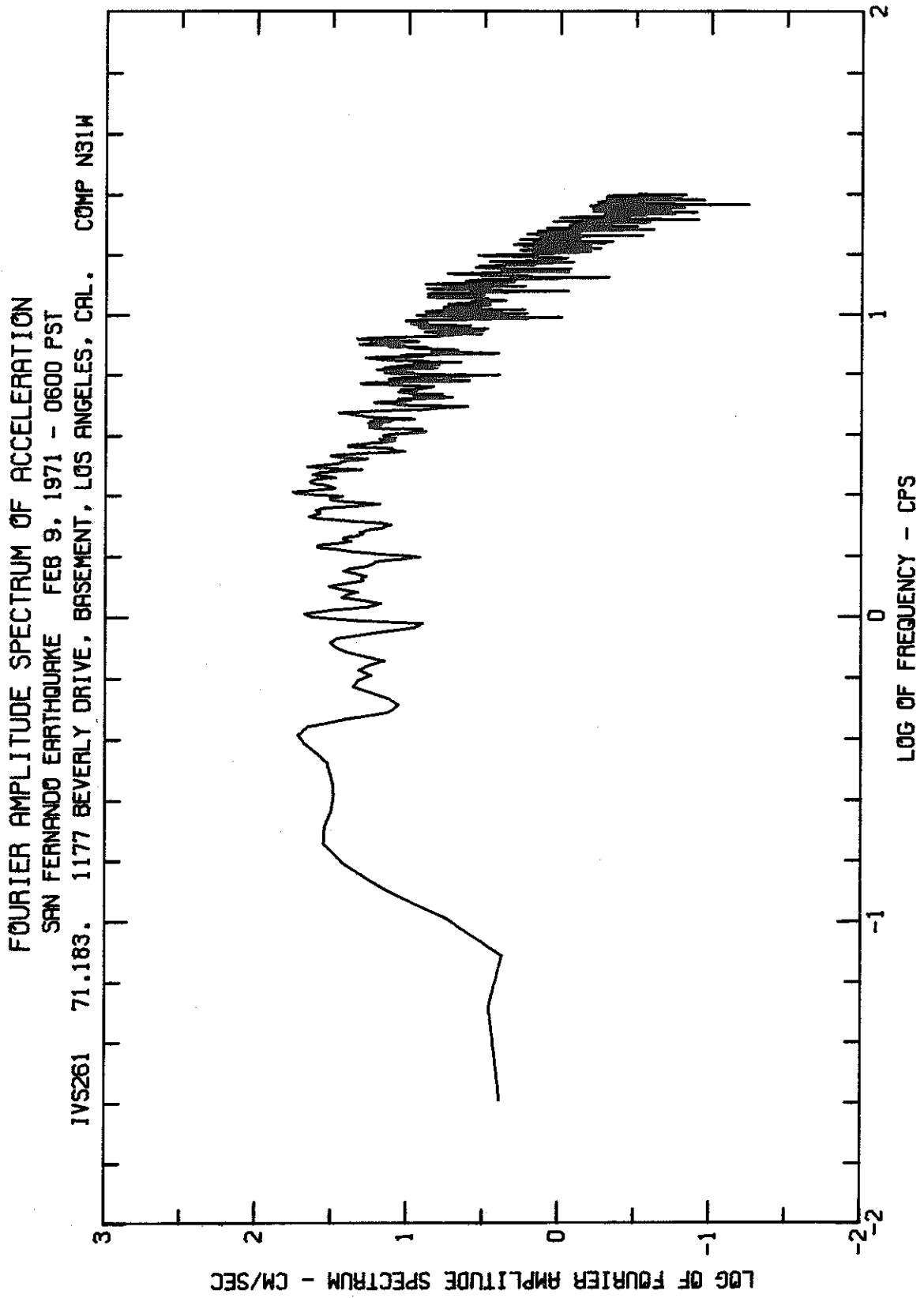








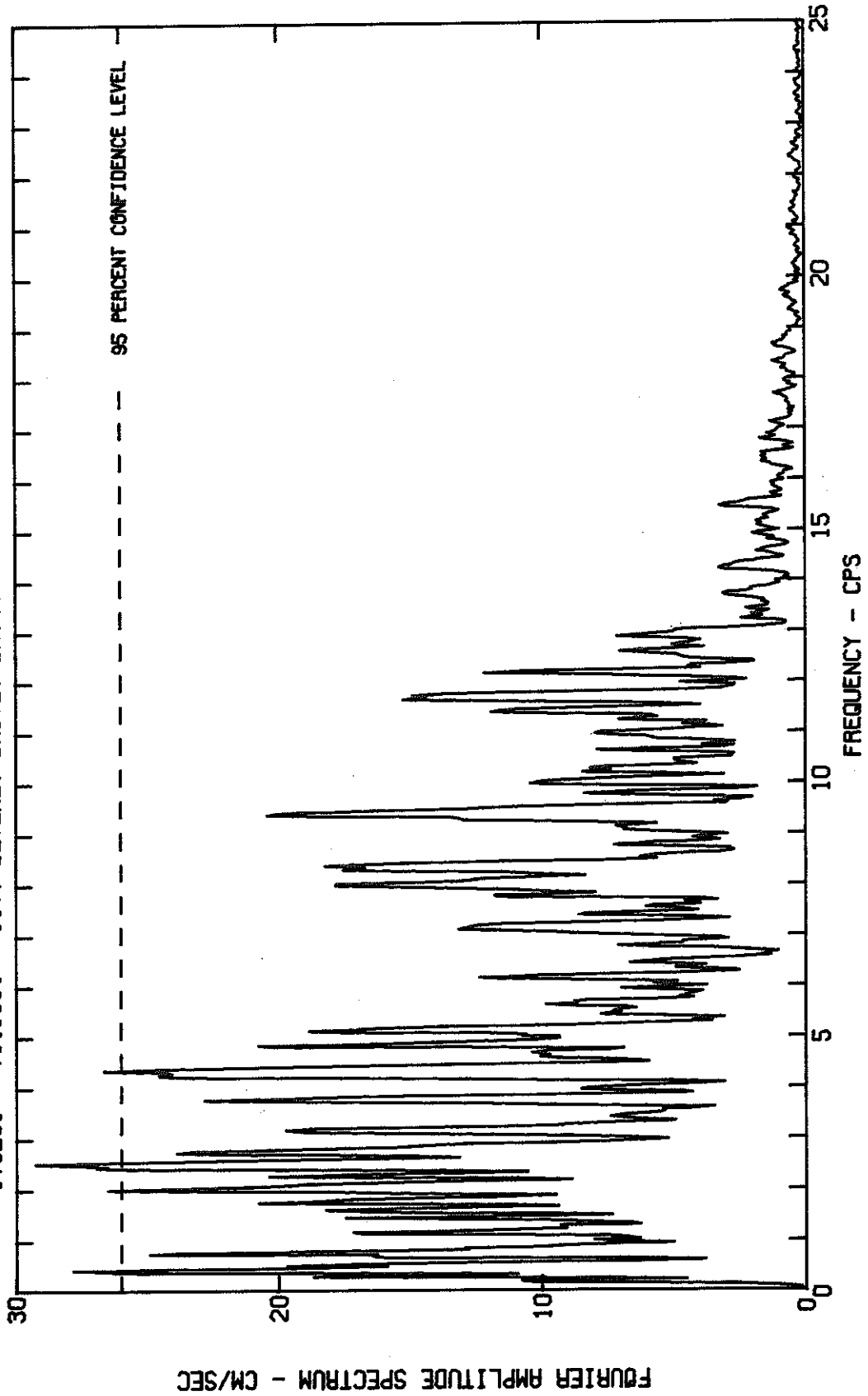


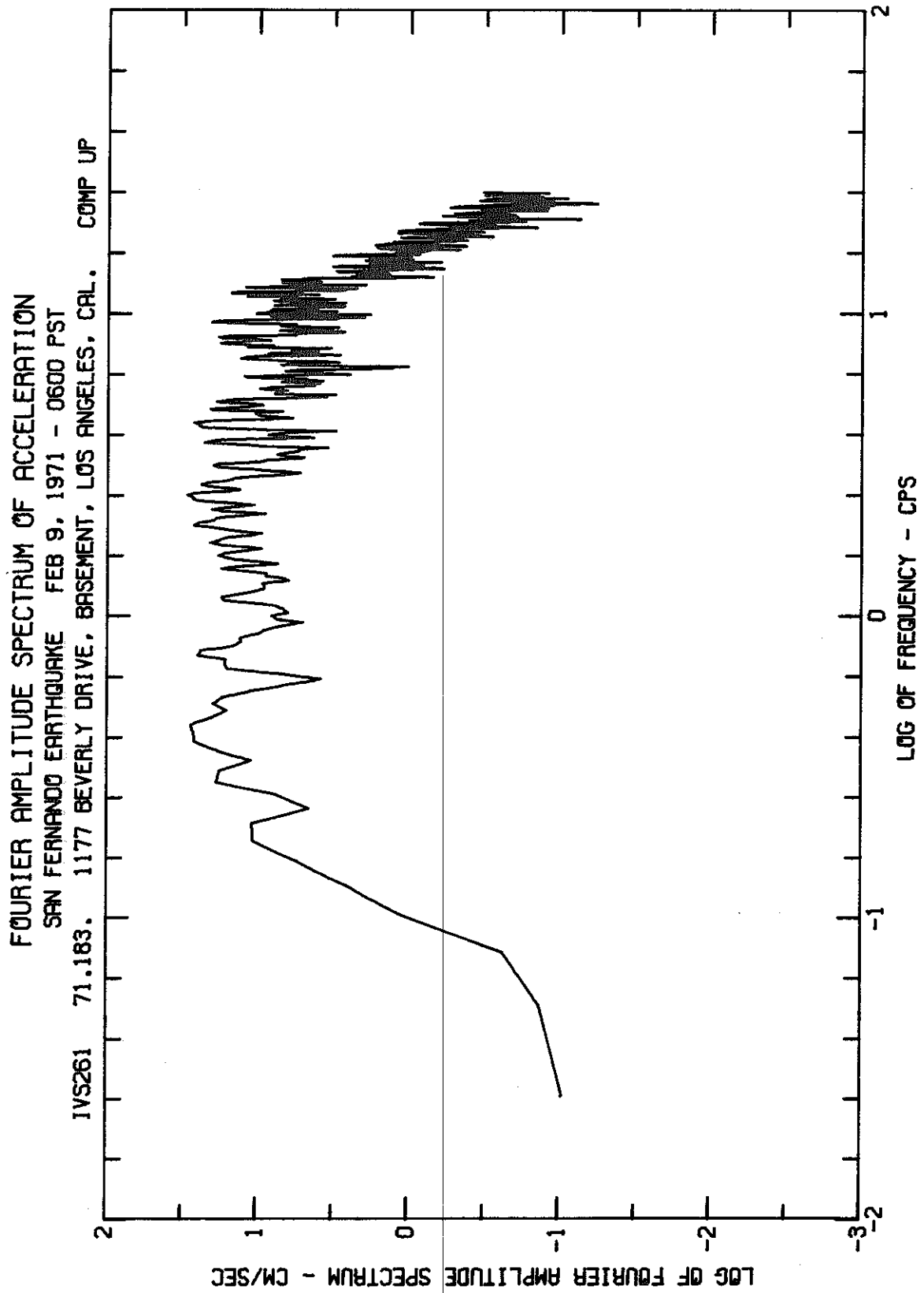


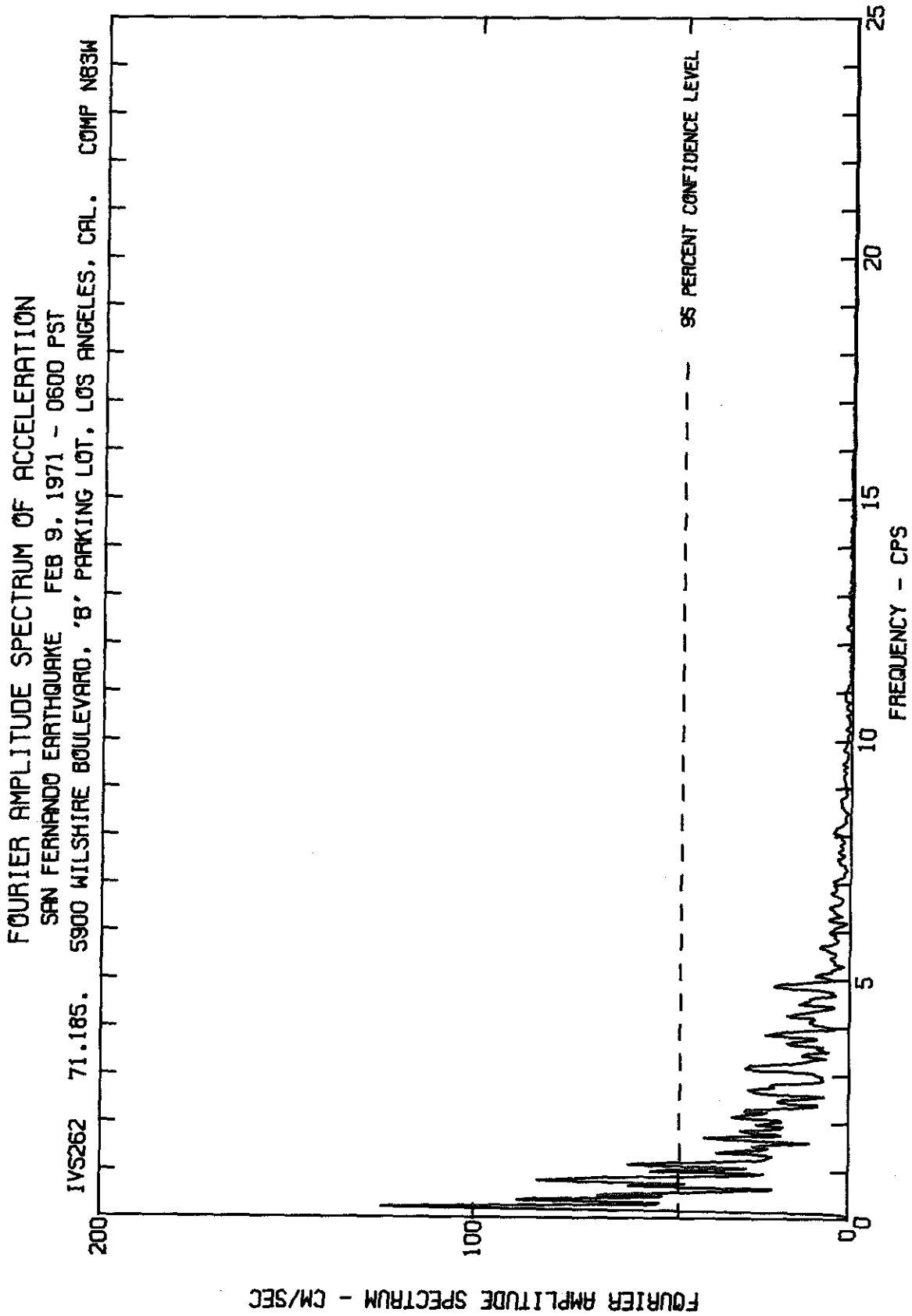
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

IVS261 71.183. 1177 BEVERLY DRIVE, BASEMENT, LOS ANGELES, CAL. COMP UP



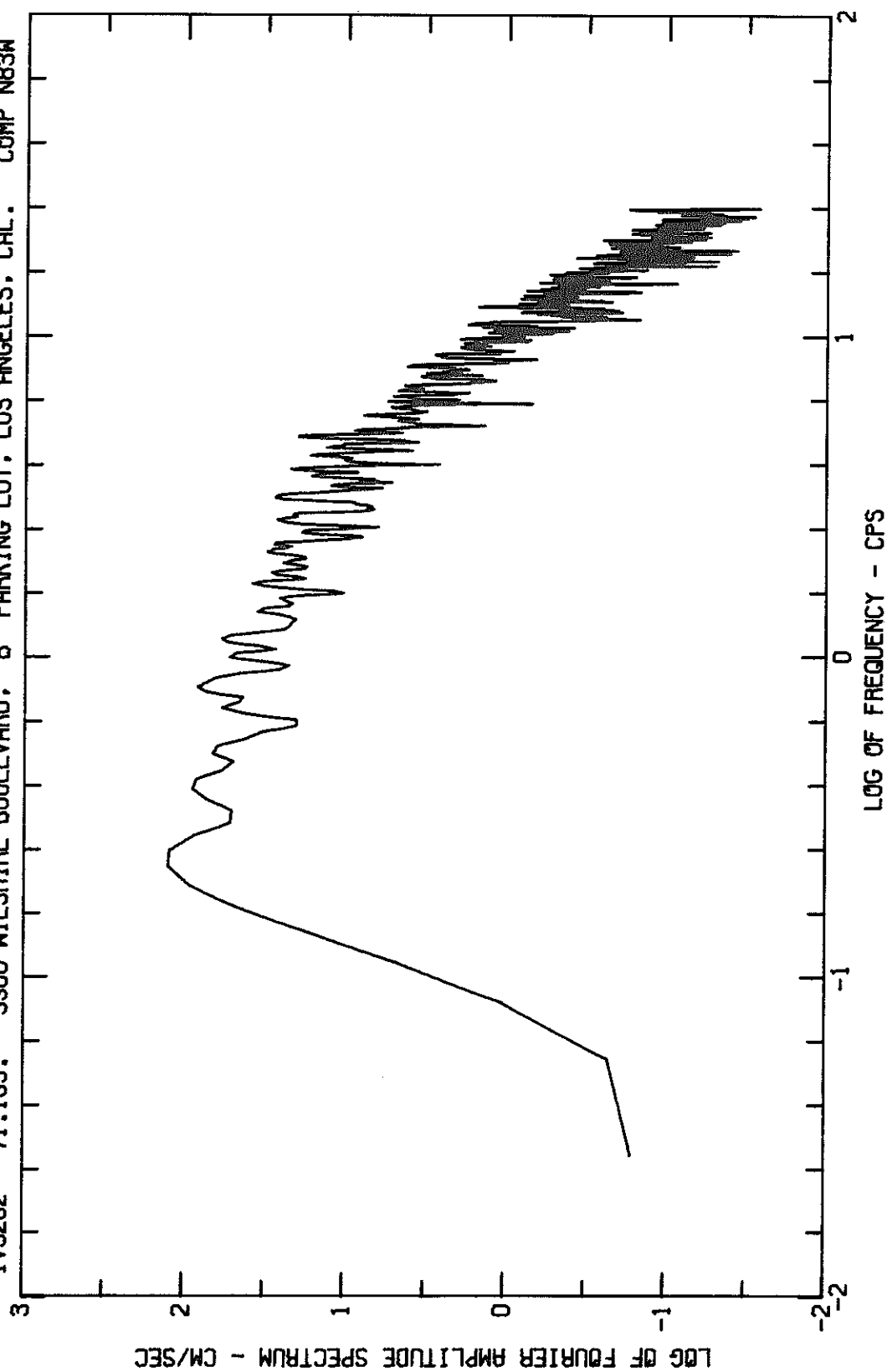


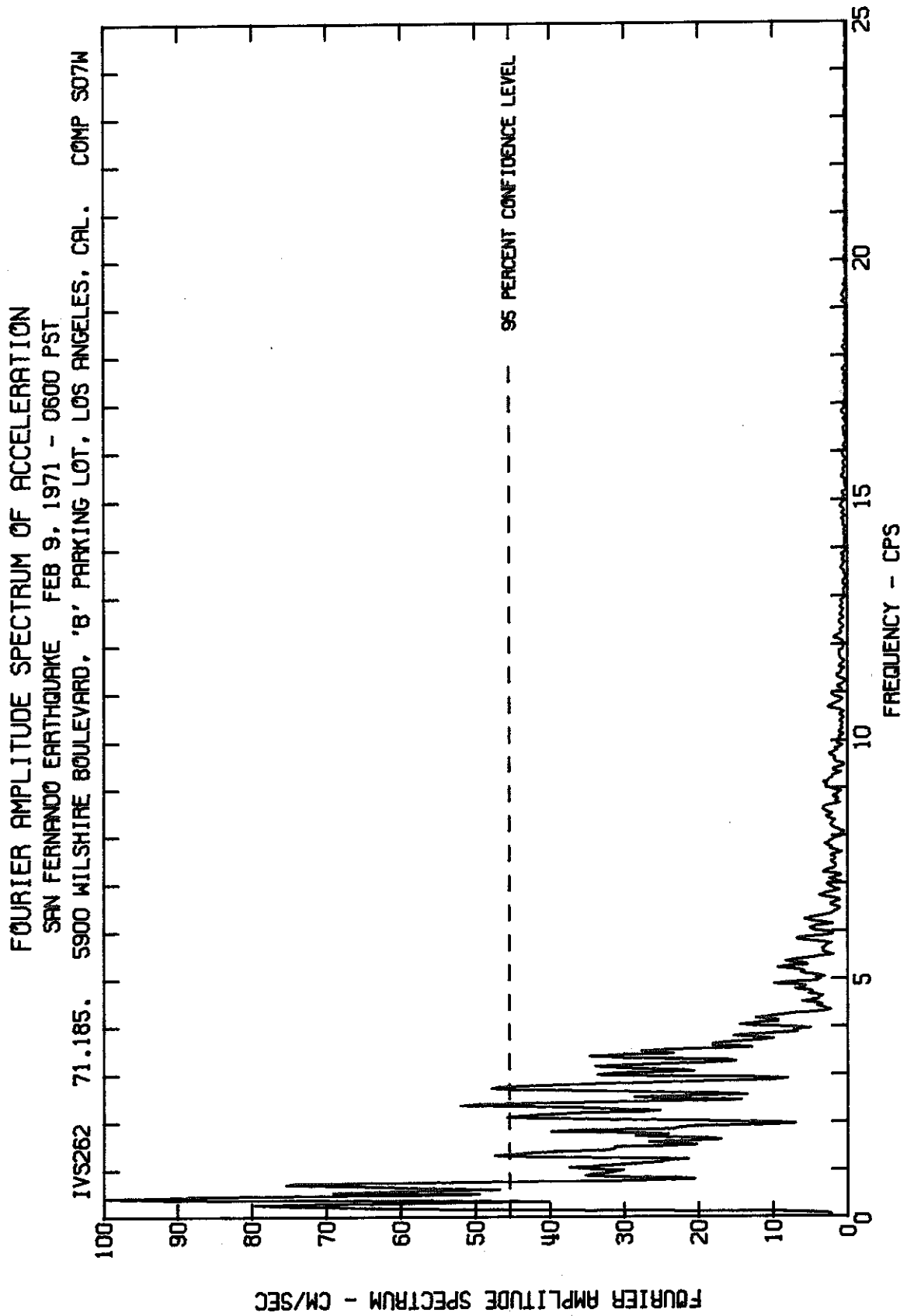


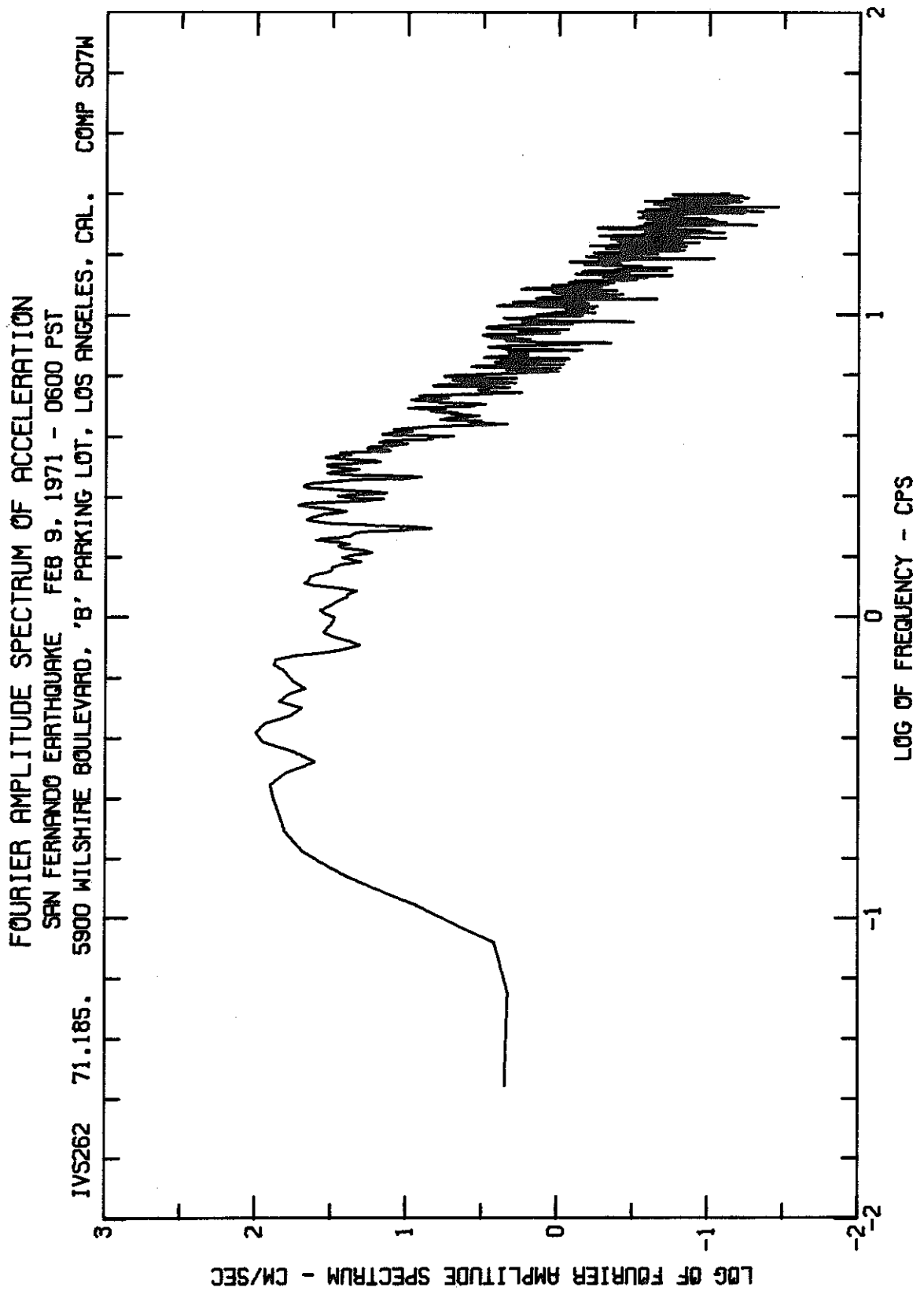
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

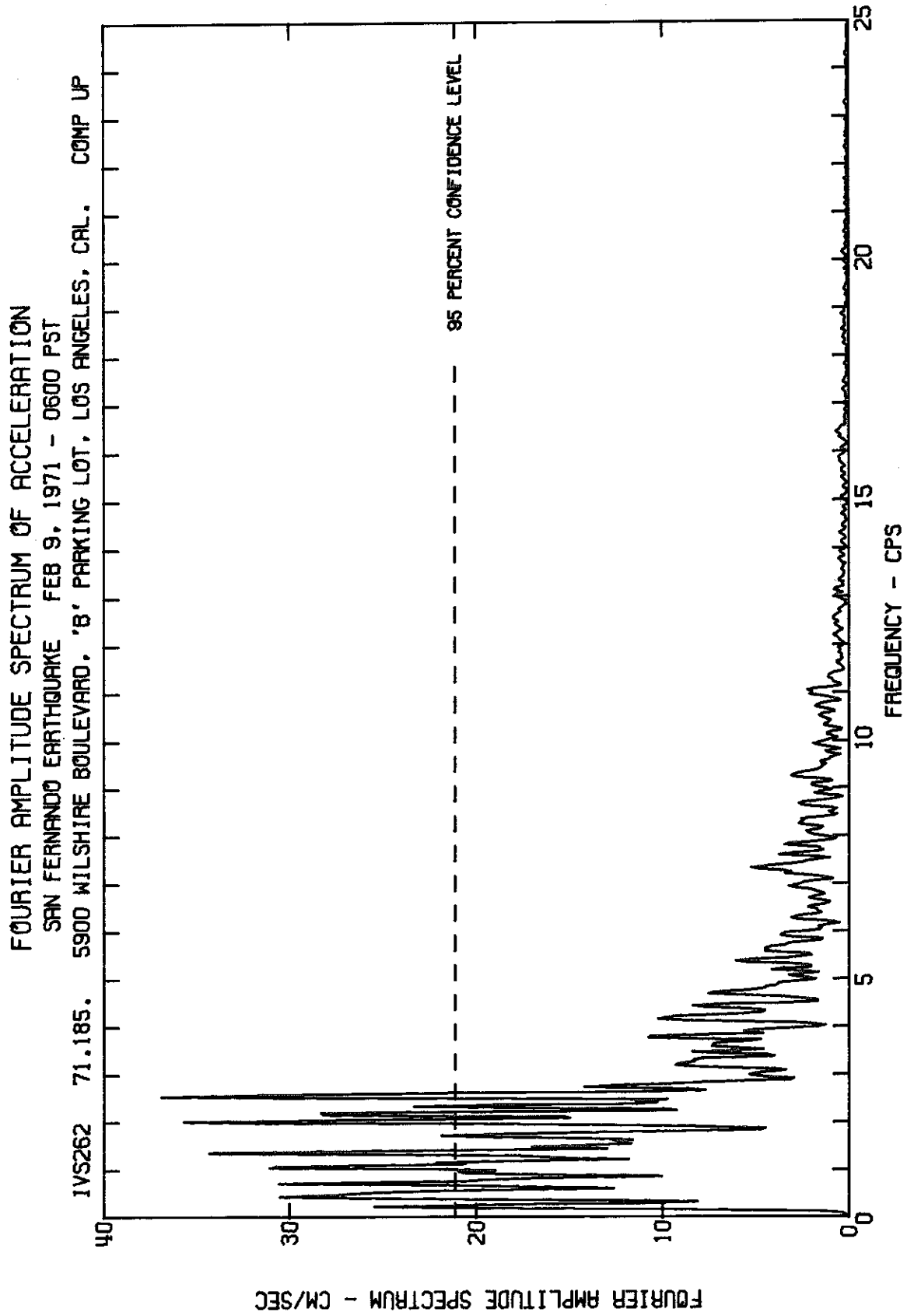
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

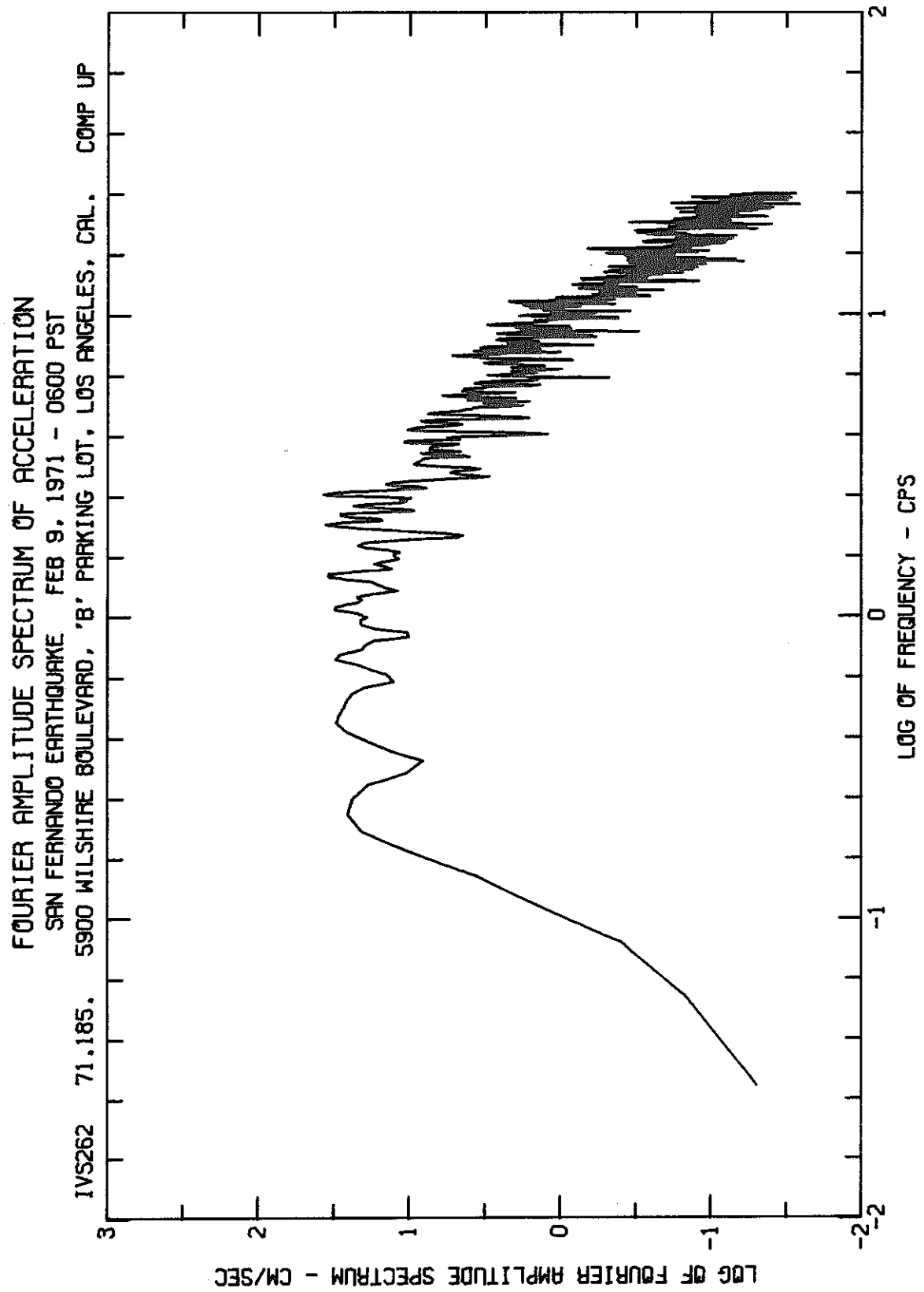
IVS262 71.185. 5900 WILSHIRE BOULEVARD, 'B' PARKING LOT, LOS ANGELES, CAL. COMP N83W

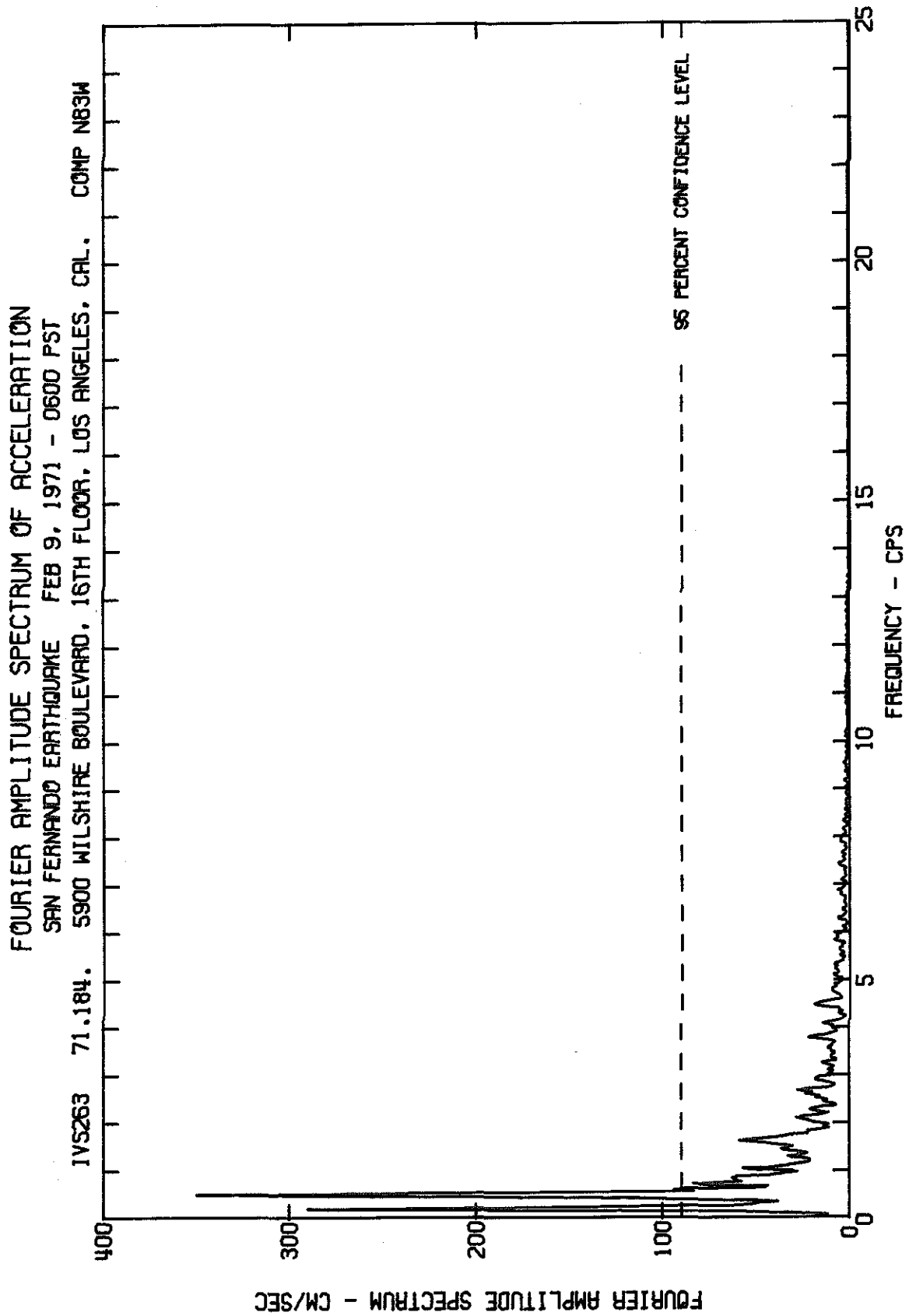


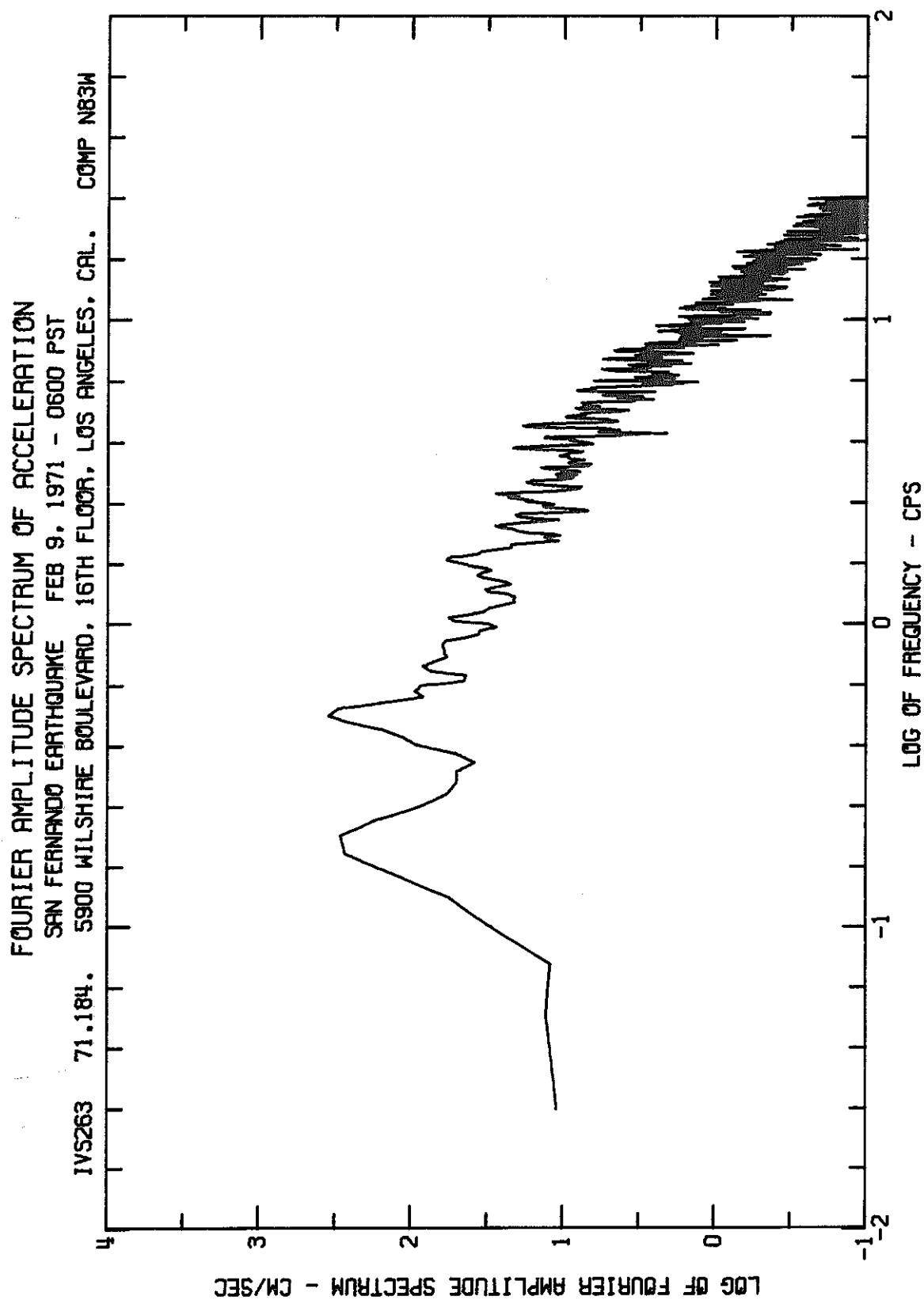








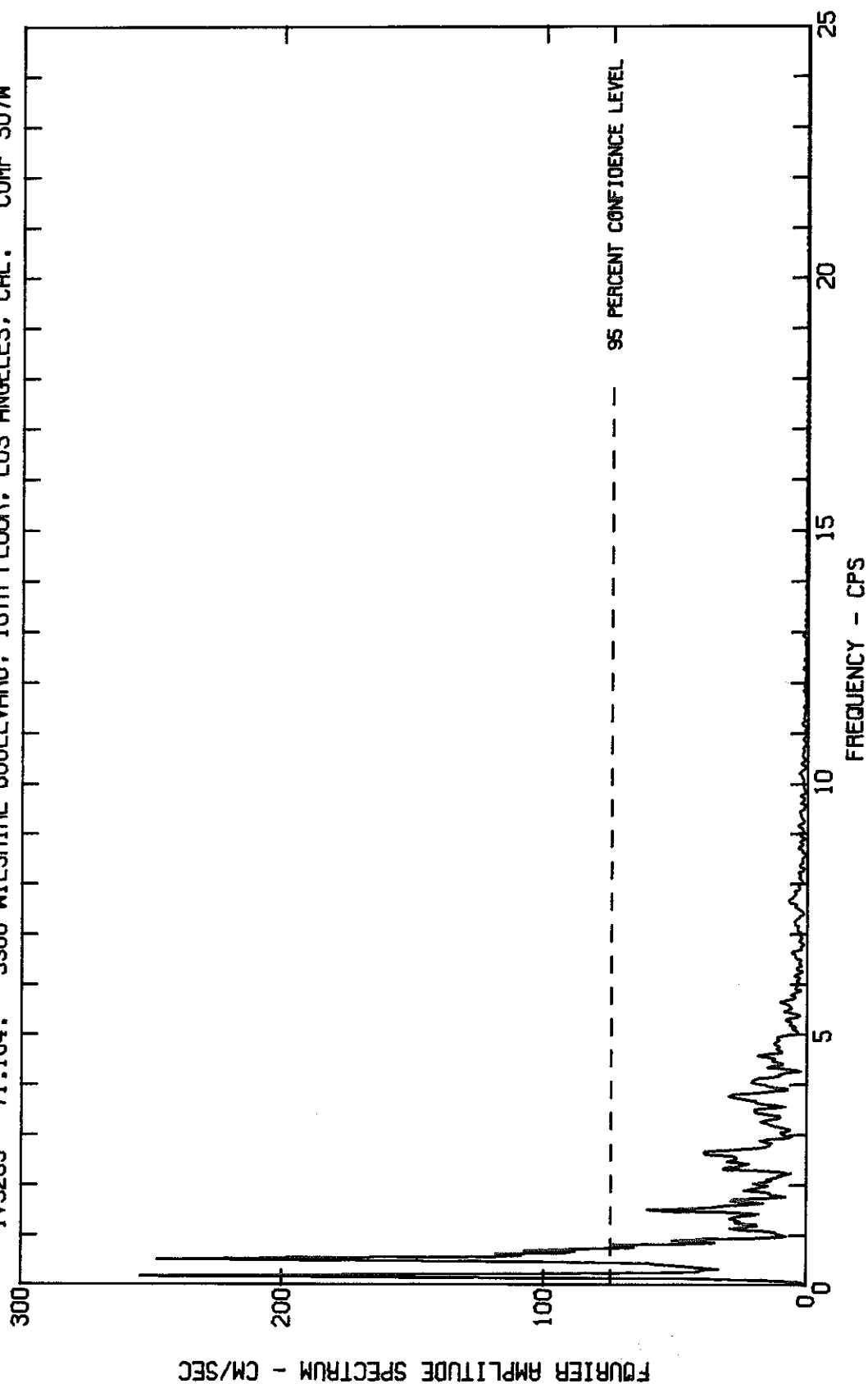


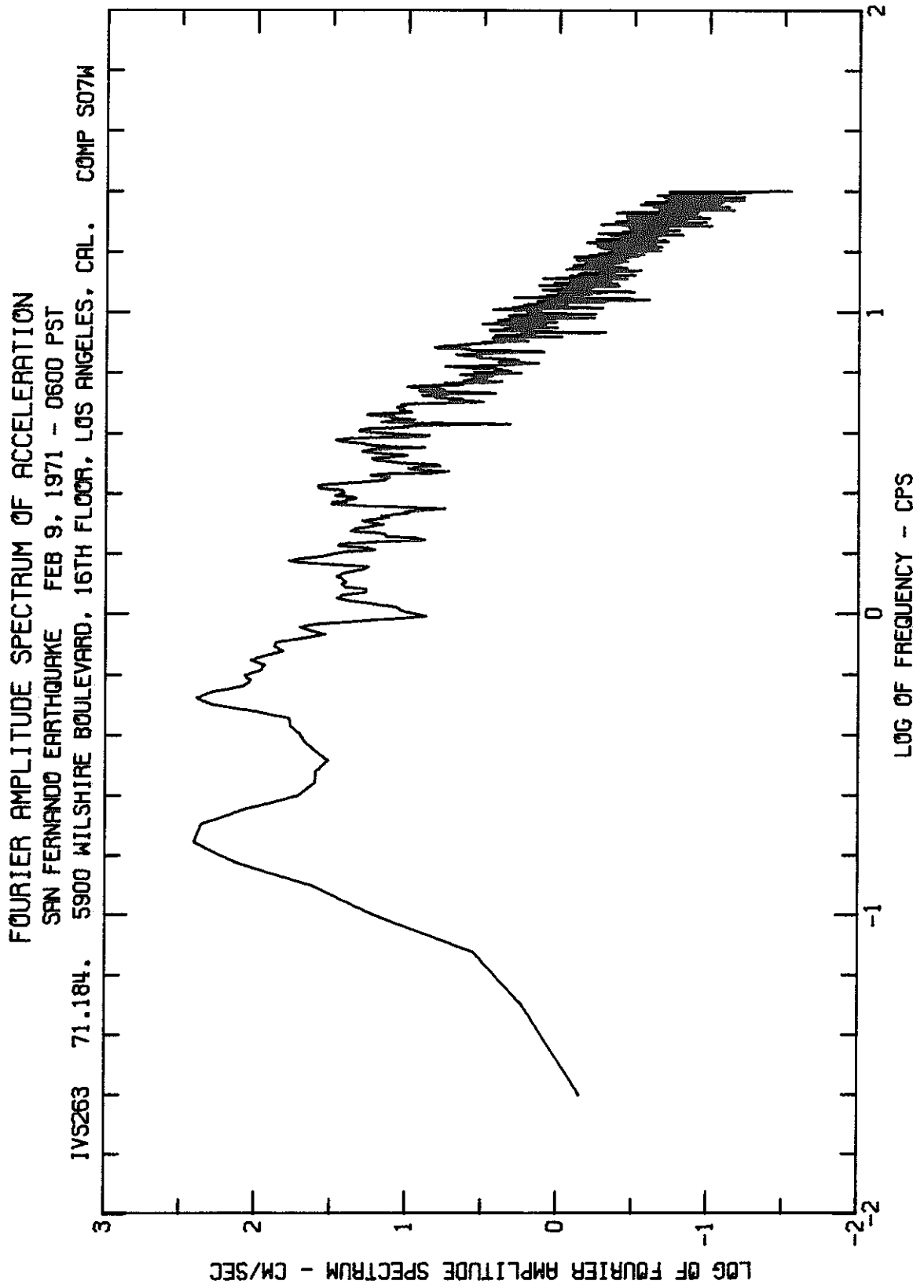


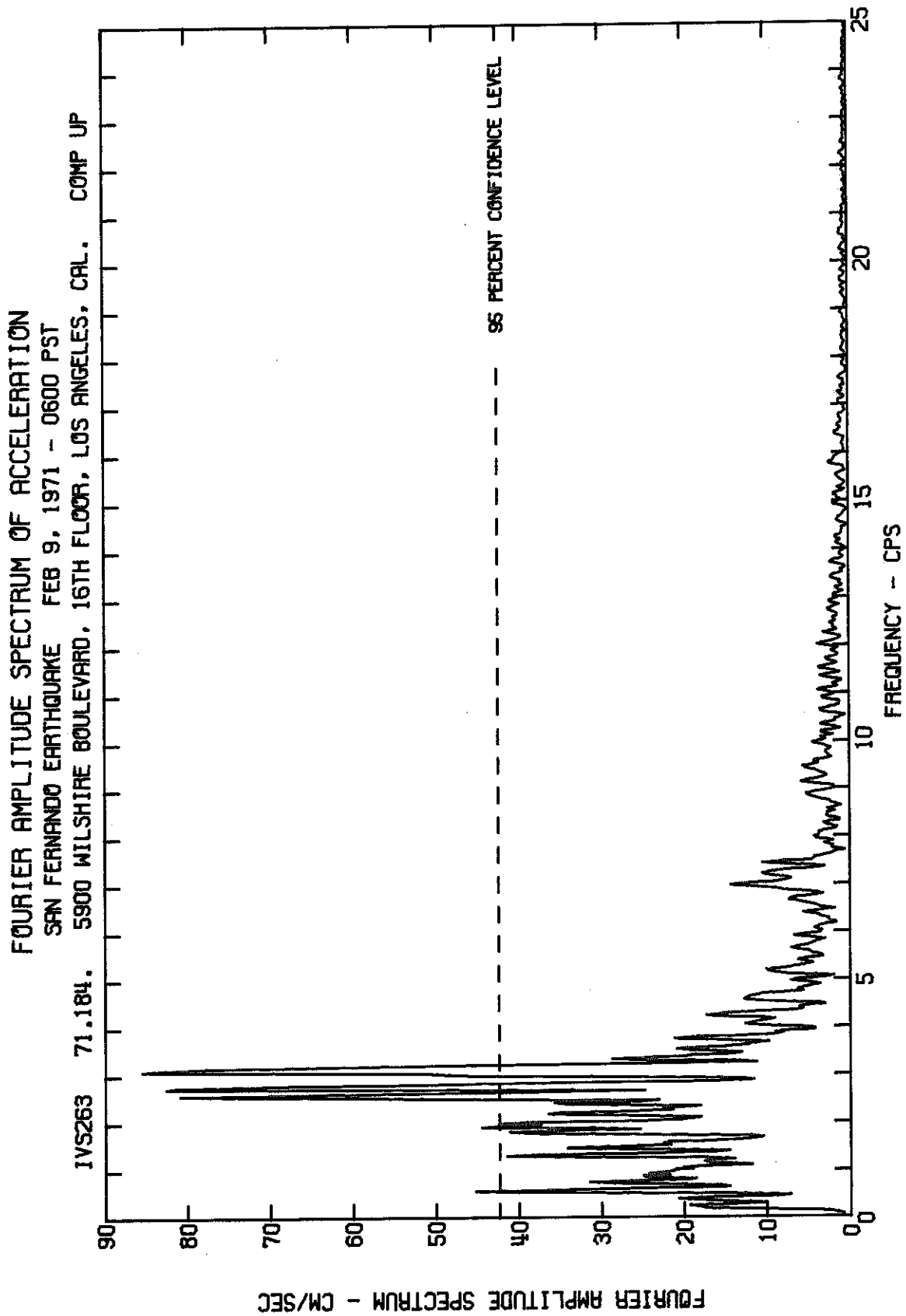
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

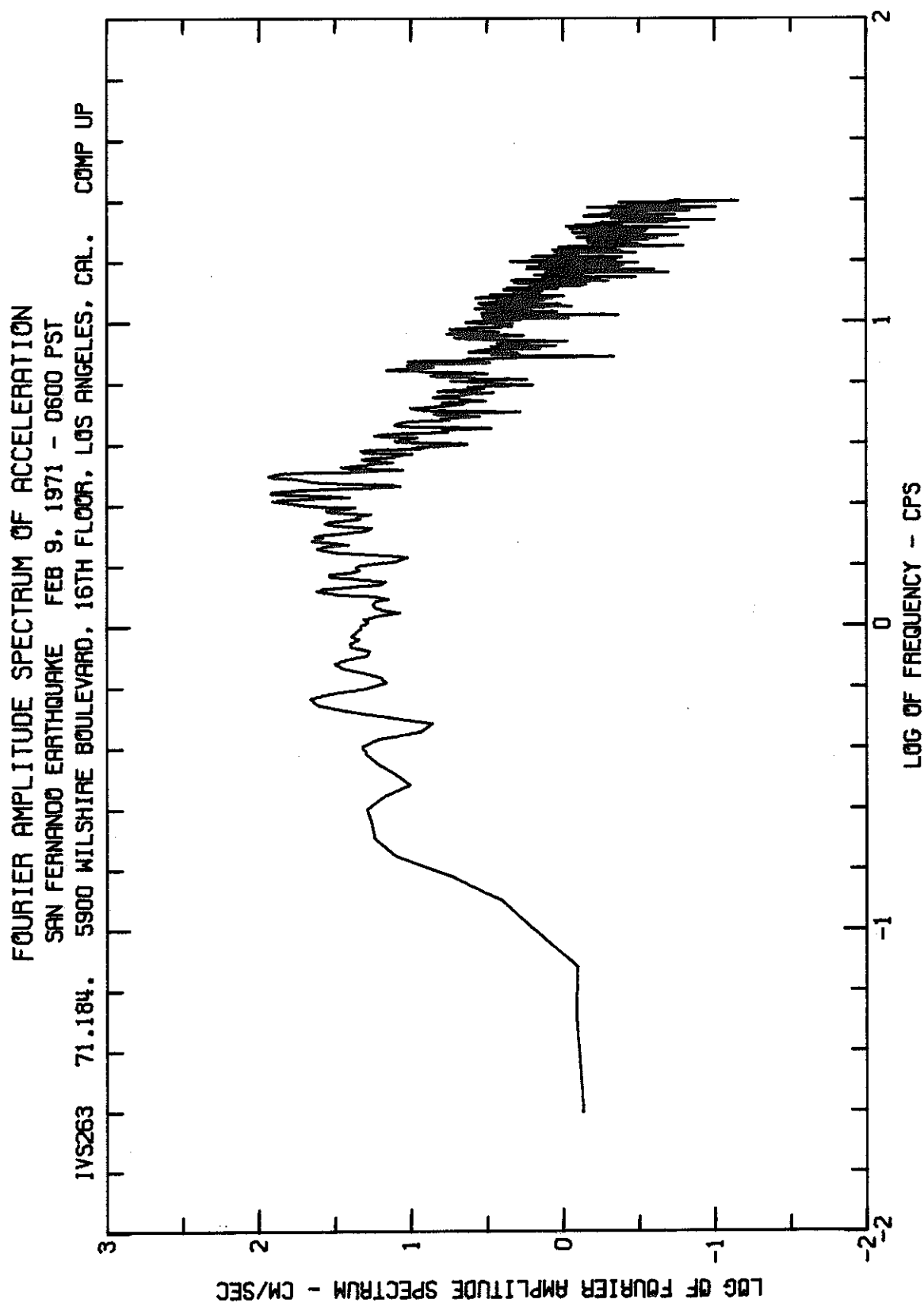
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

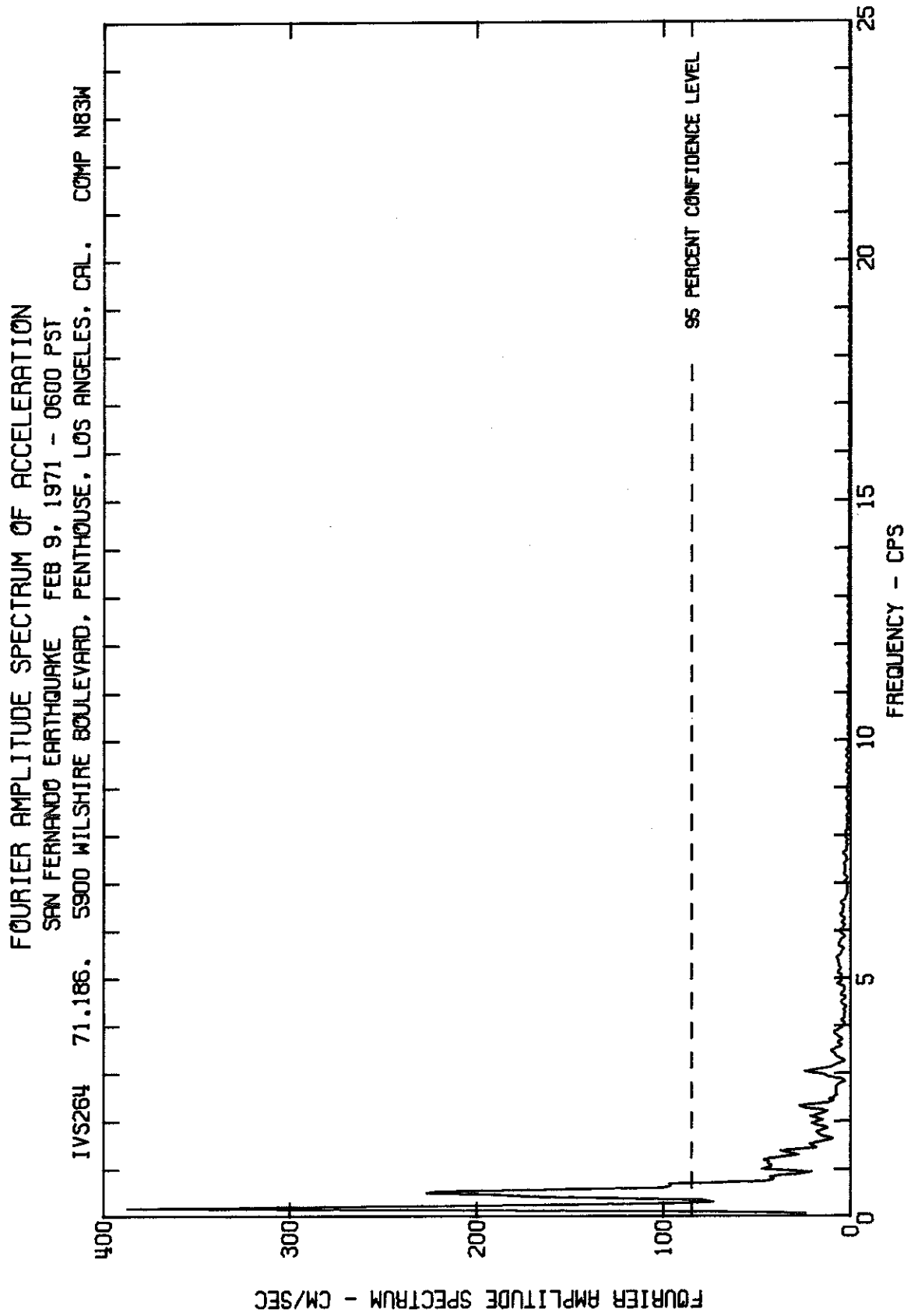
IVS263 71.184. 5900 WILSHIRE BOULEVARD, 16TH FLOOR, LOS ANGELES, CAL. COMP S07M







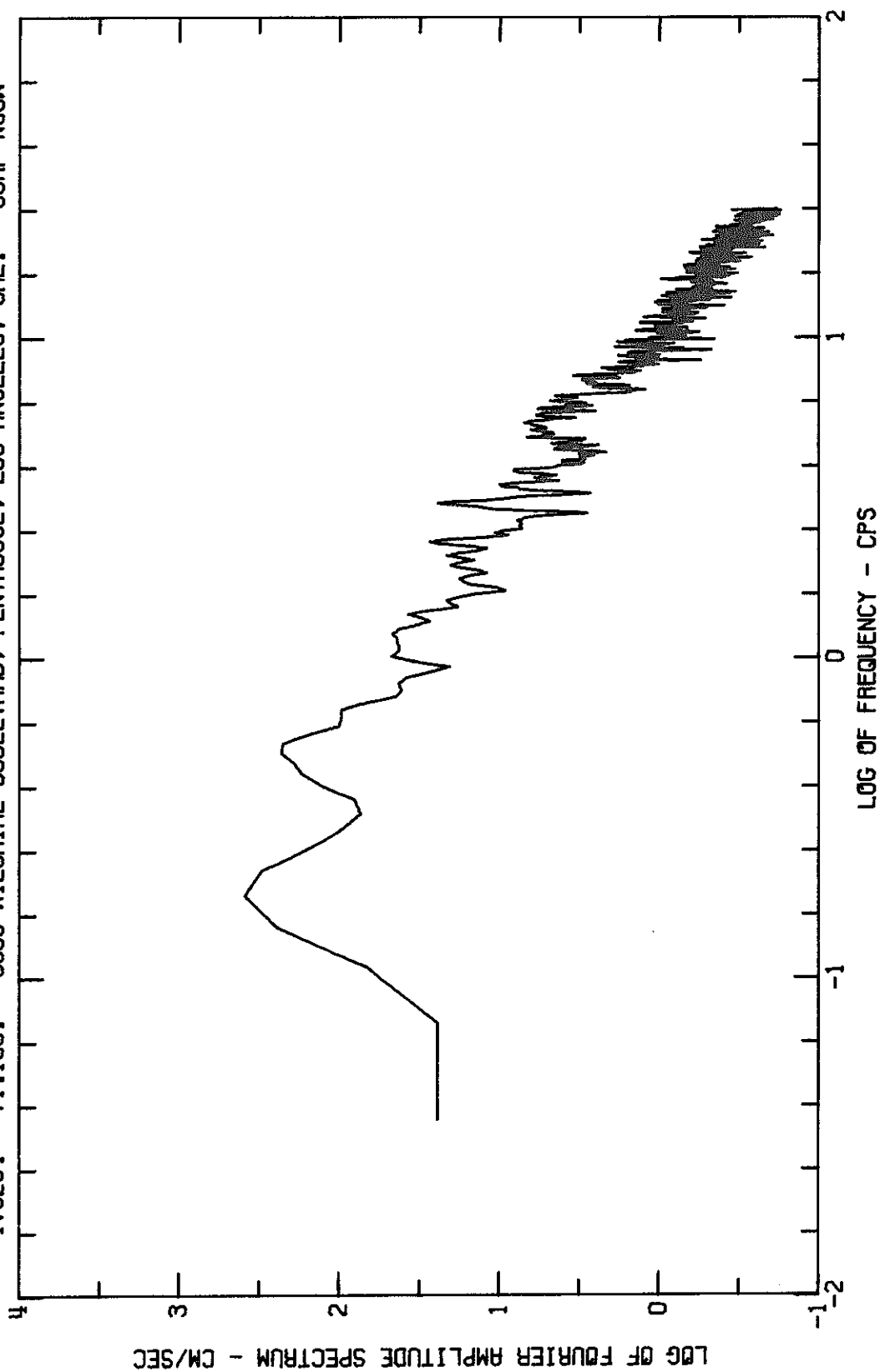


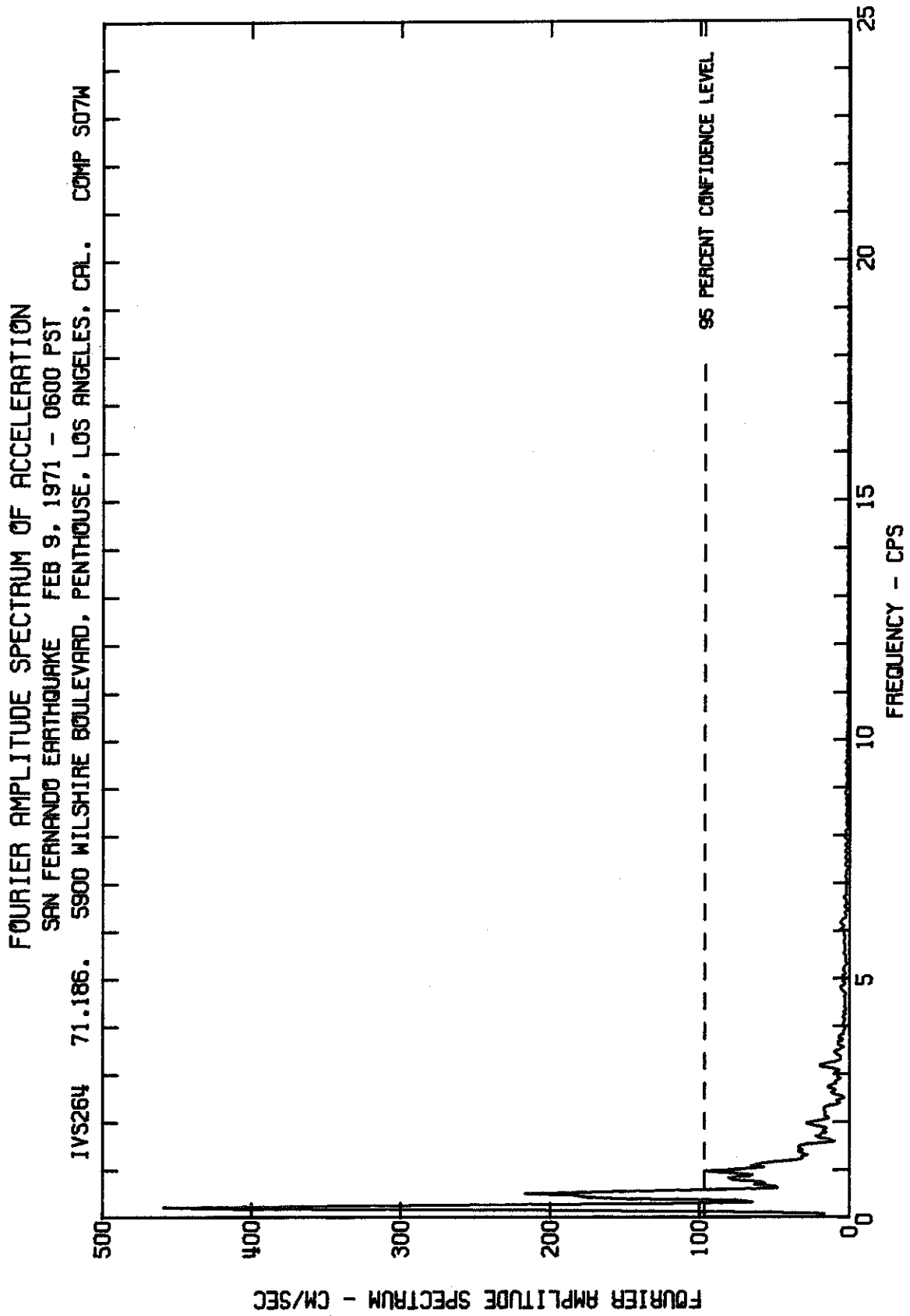


FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

IVS264 71.186. 5900 WILSHIRE BOULEVARD, PENTHOUSE, LOS ANGELES, CAL. COMP N83W

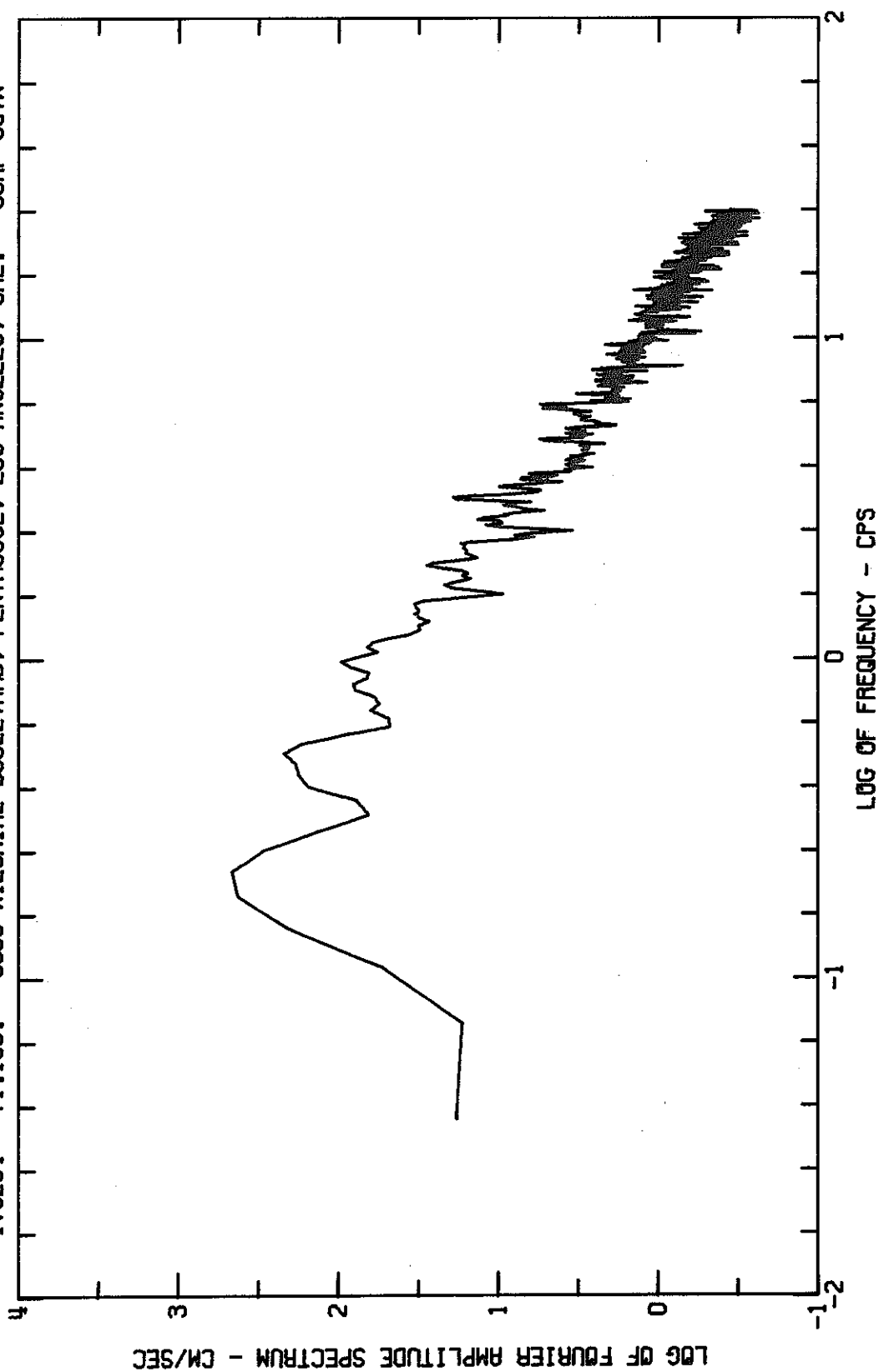


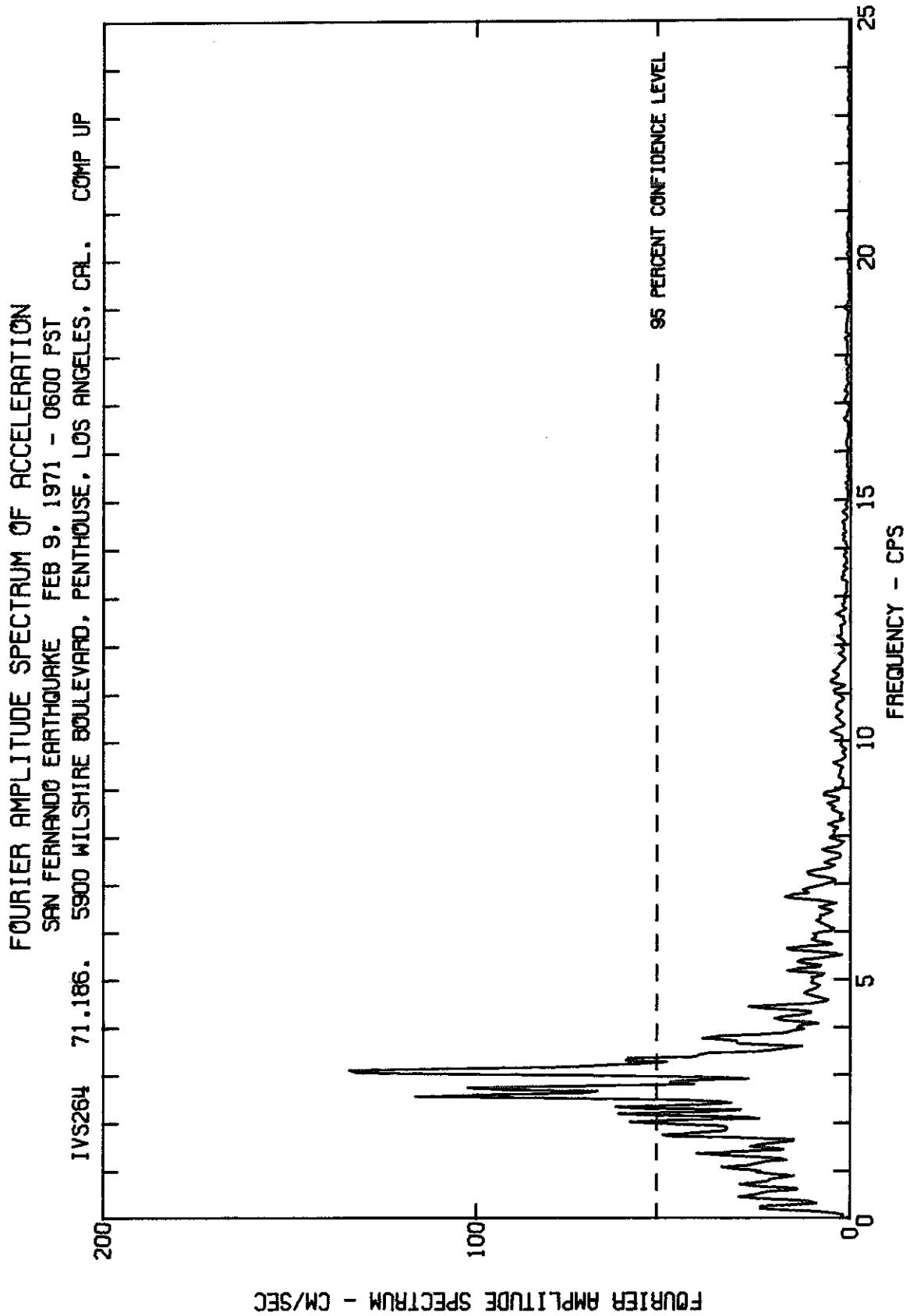


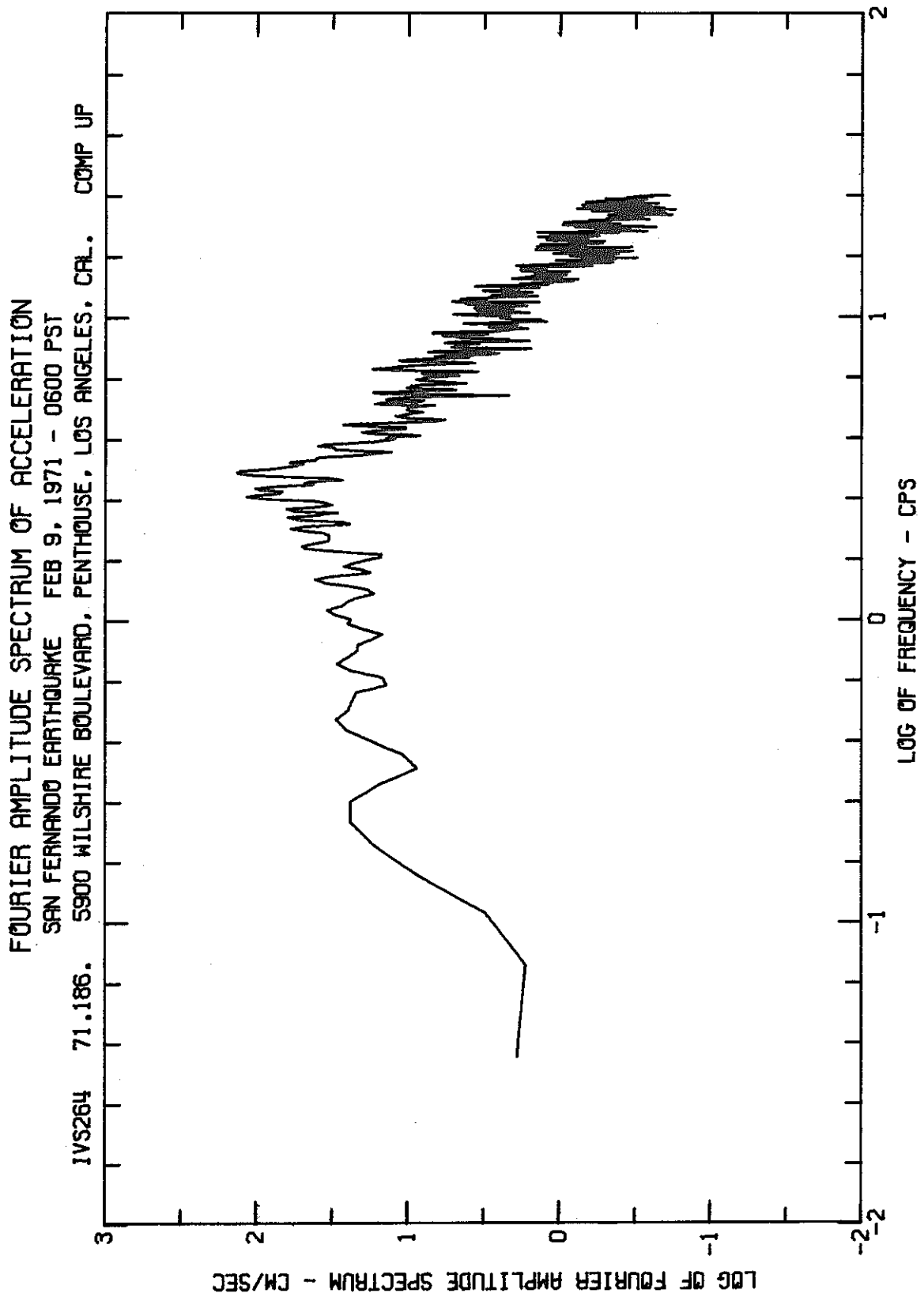
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

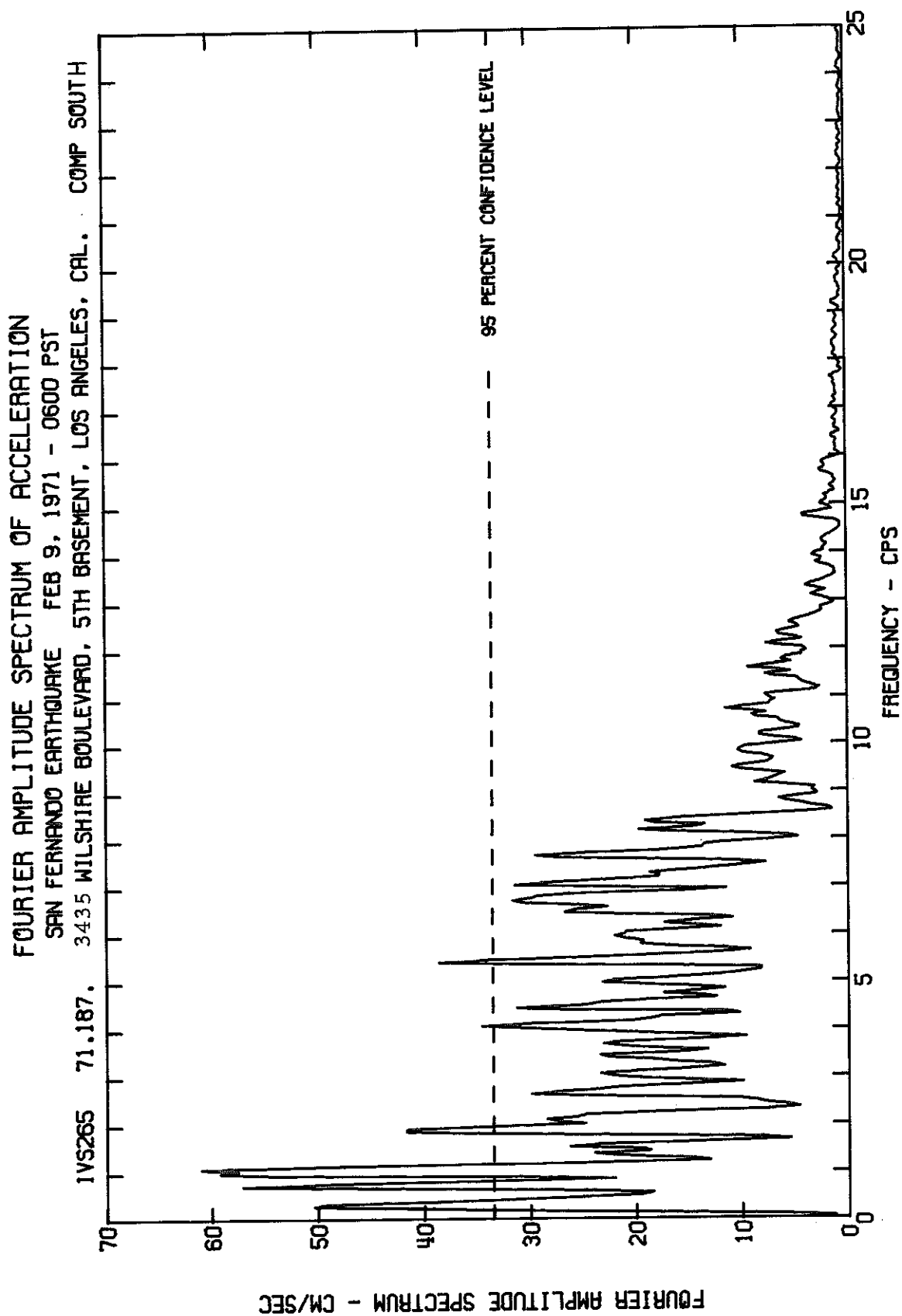
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

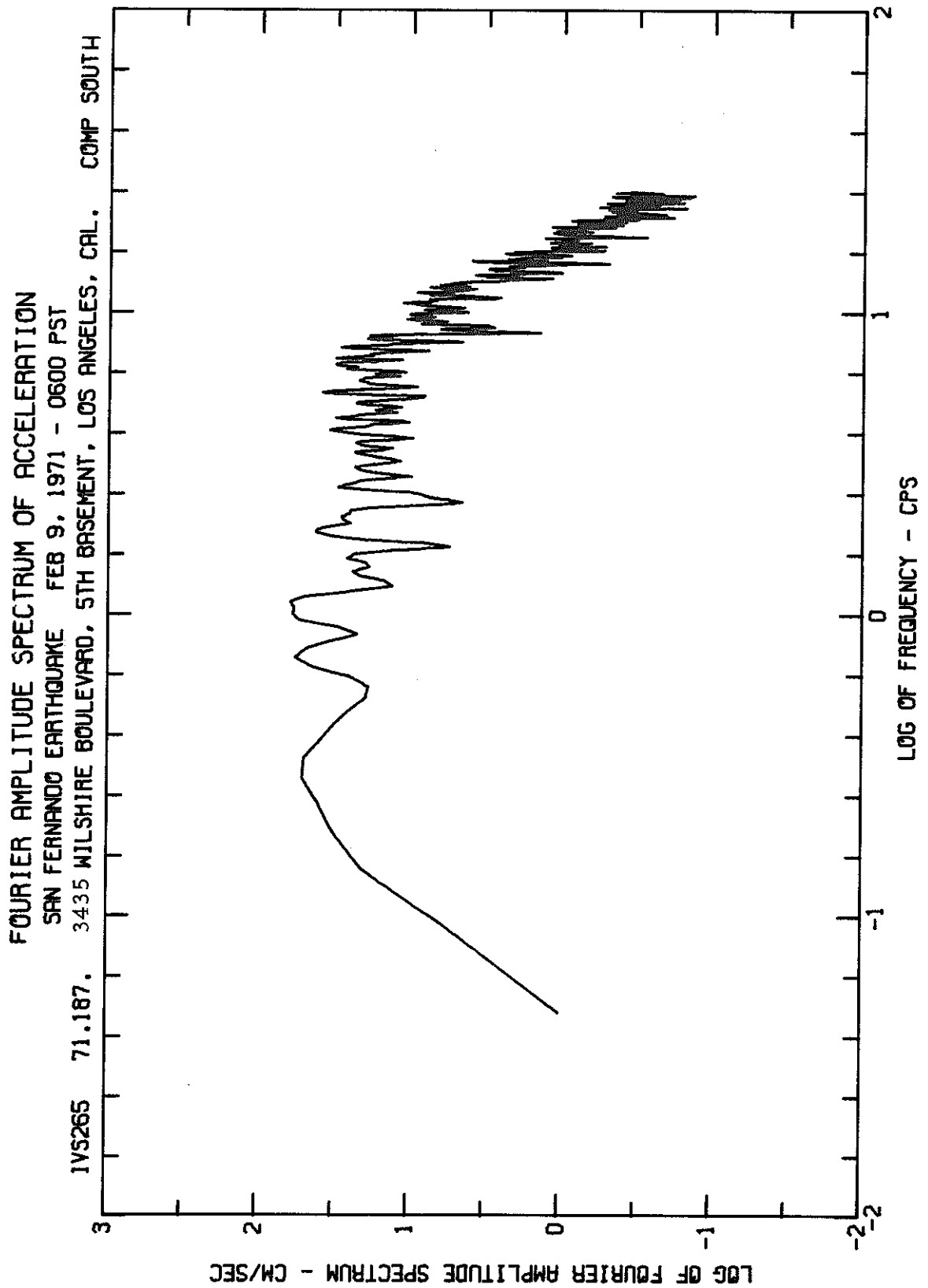
IVS264 71.186. 5900 WILSHIRE BOULEVARD, PENTHOUSE, LOS ANGELES, CAL. COMP S07M

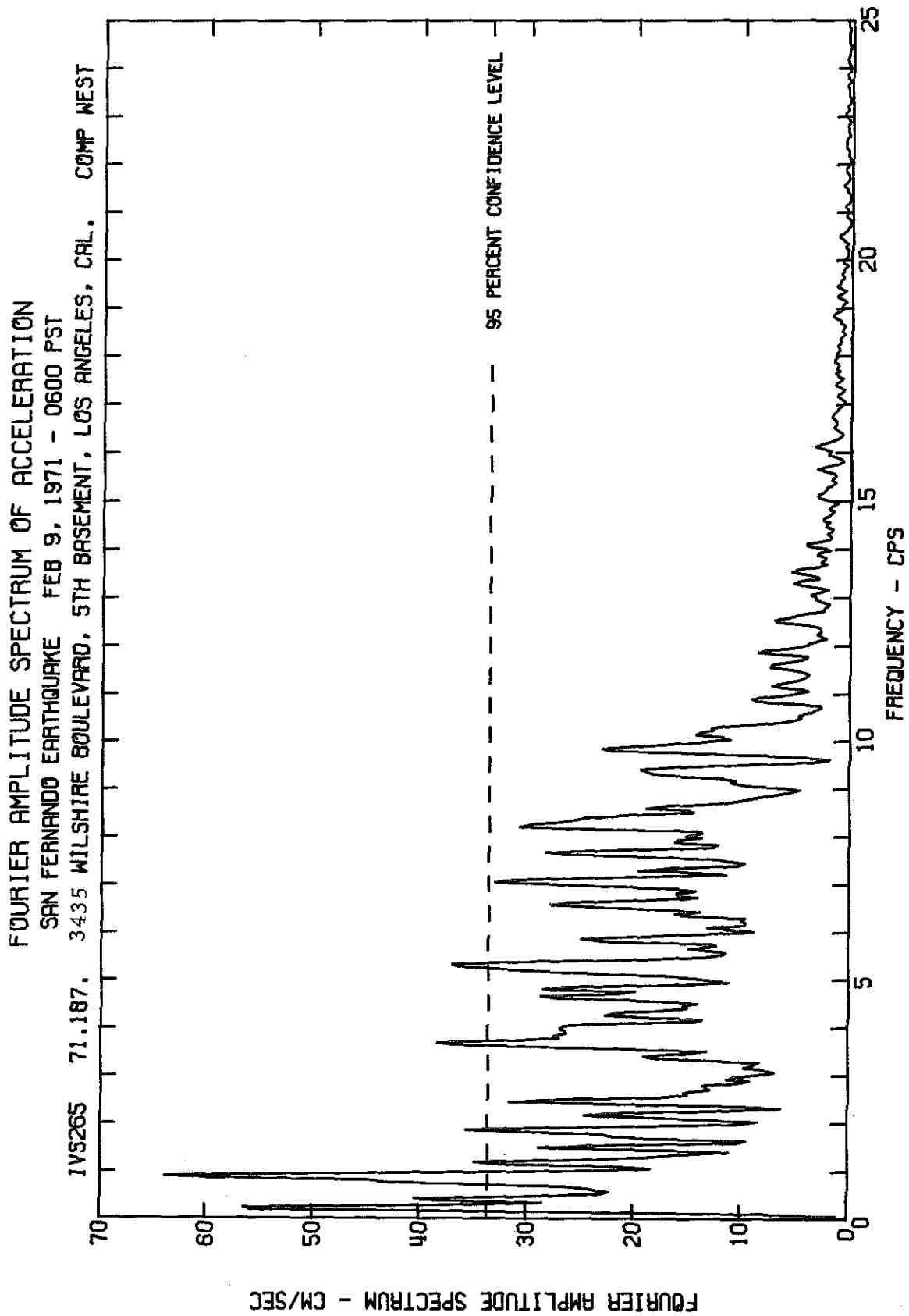


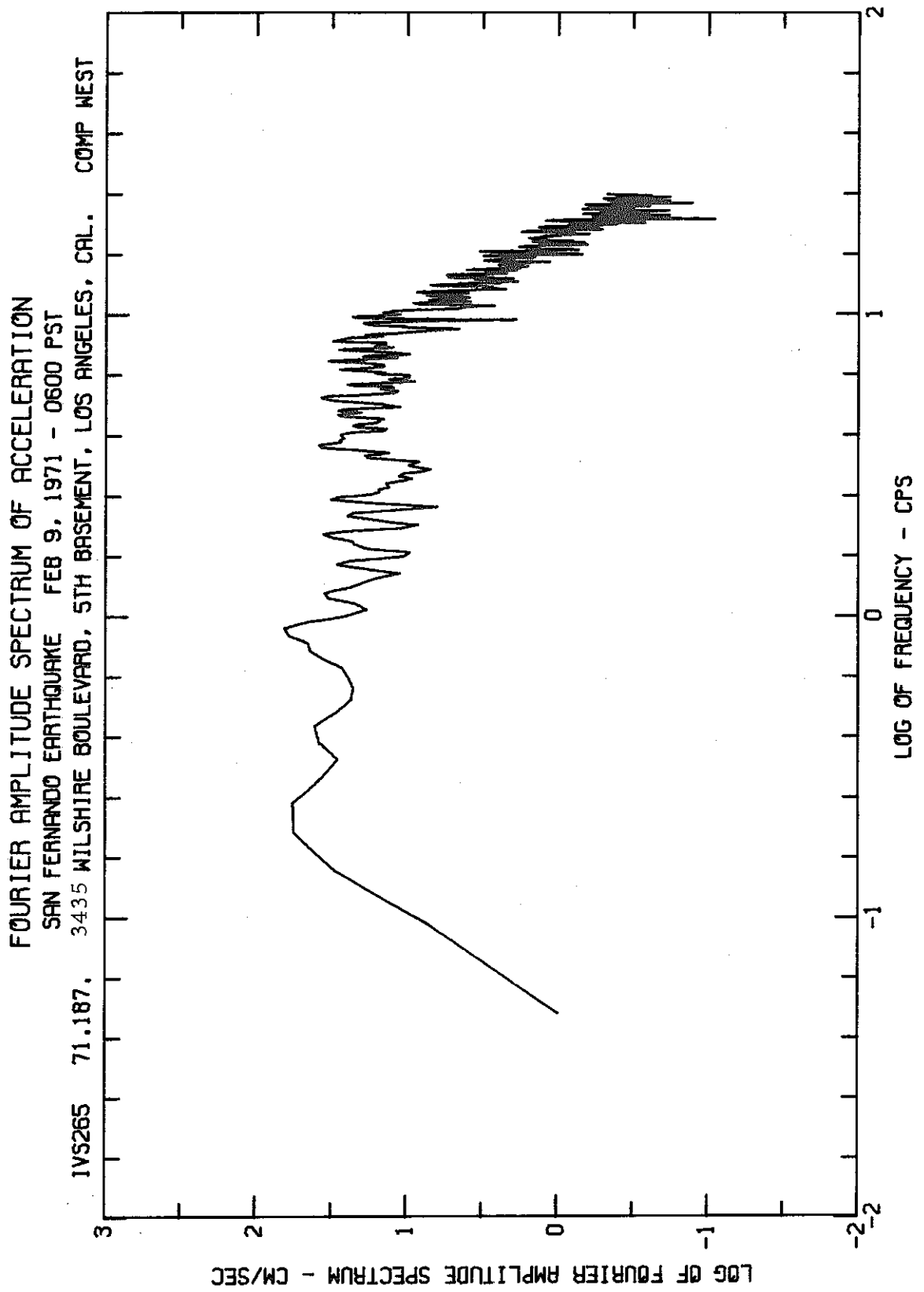


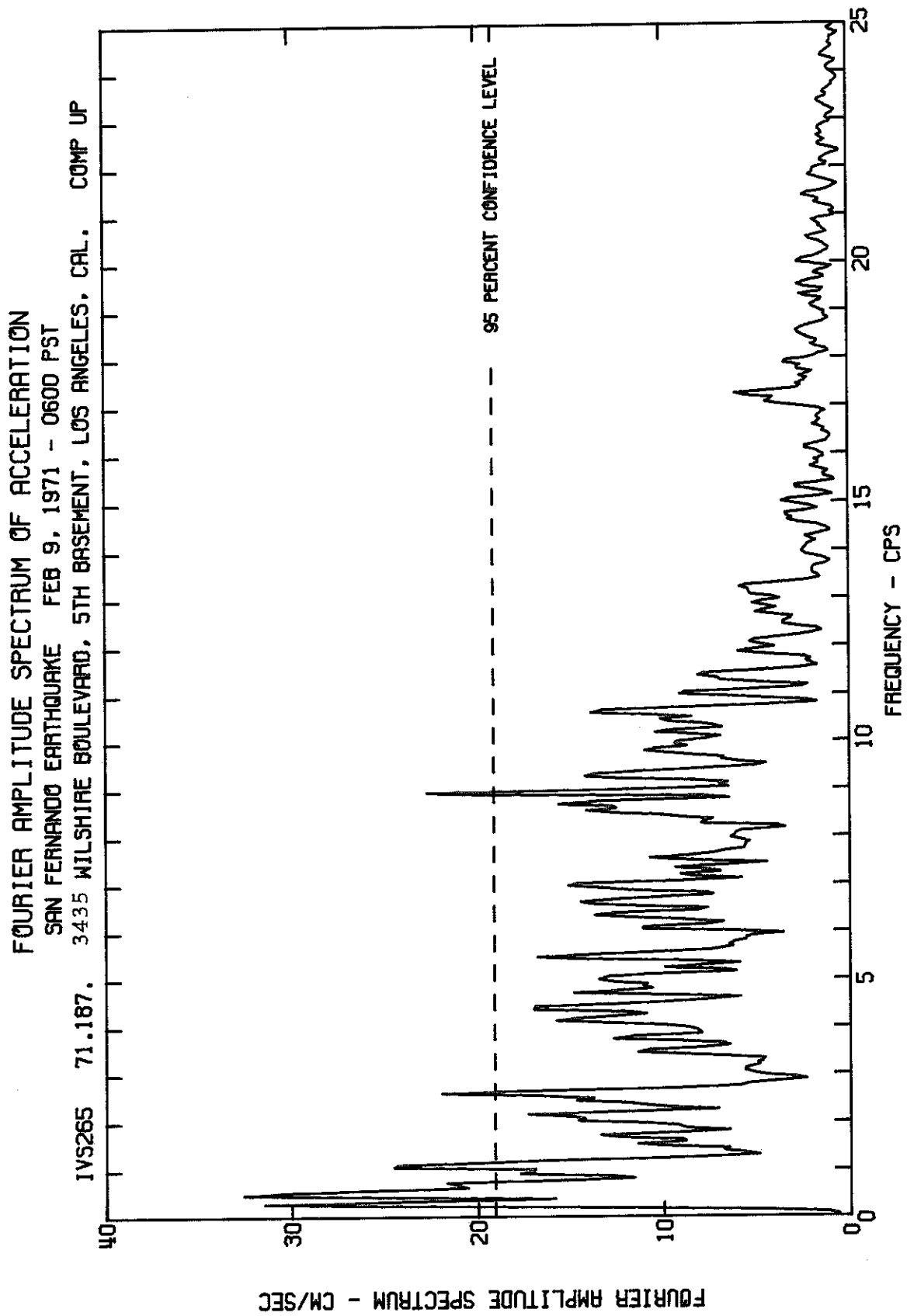


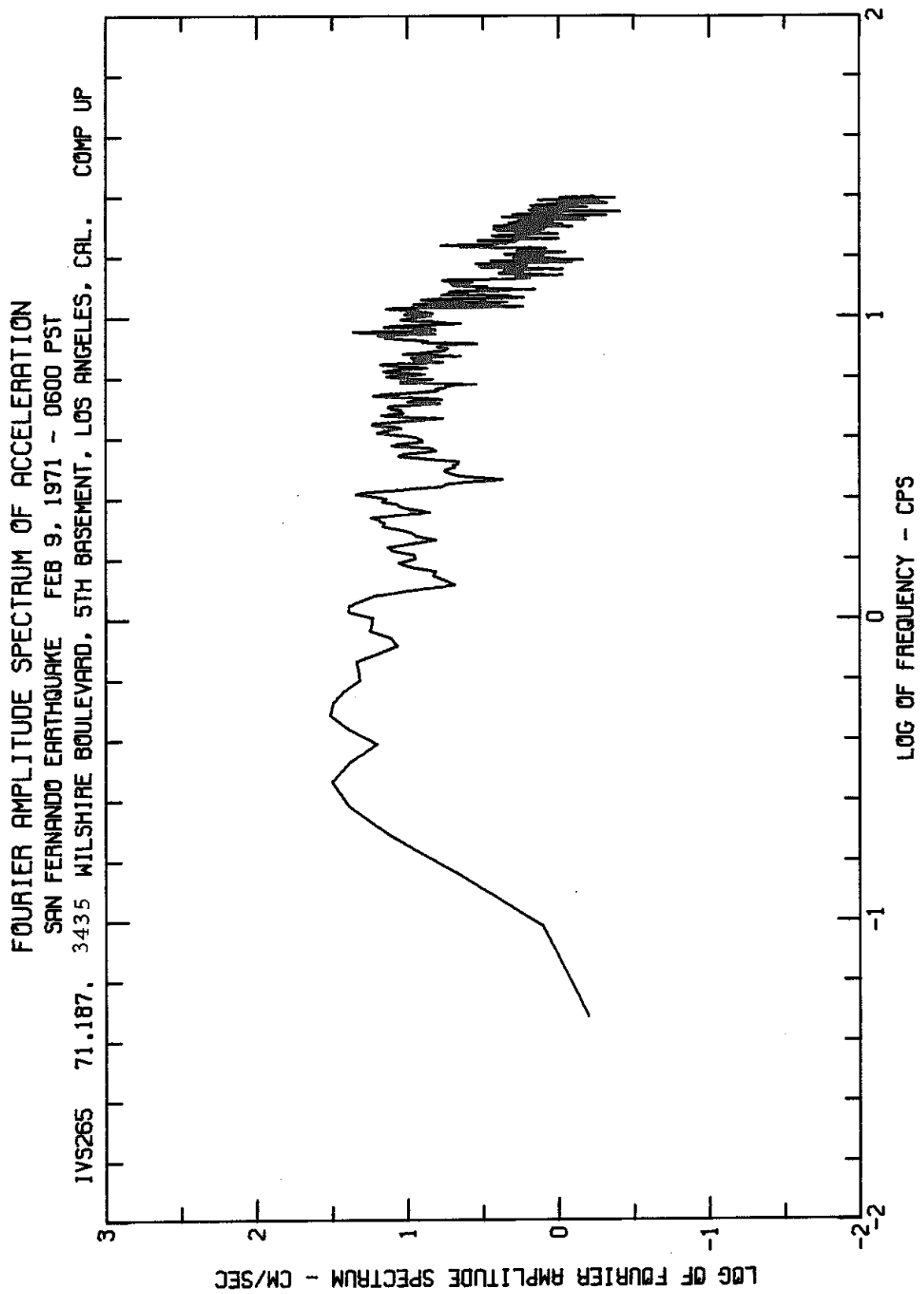








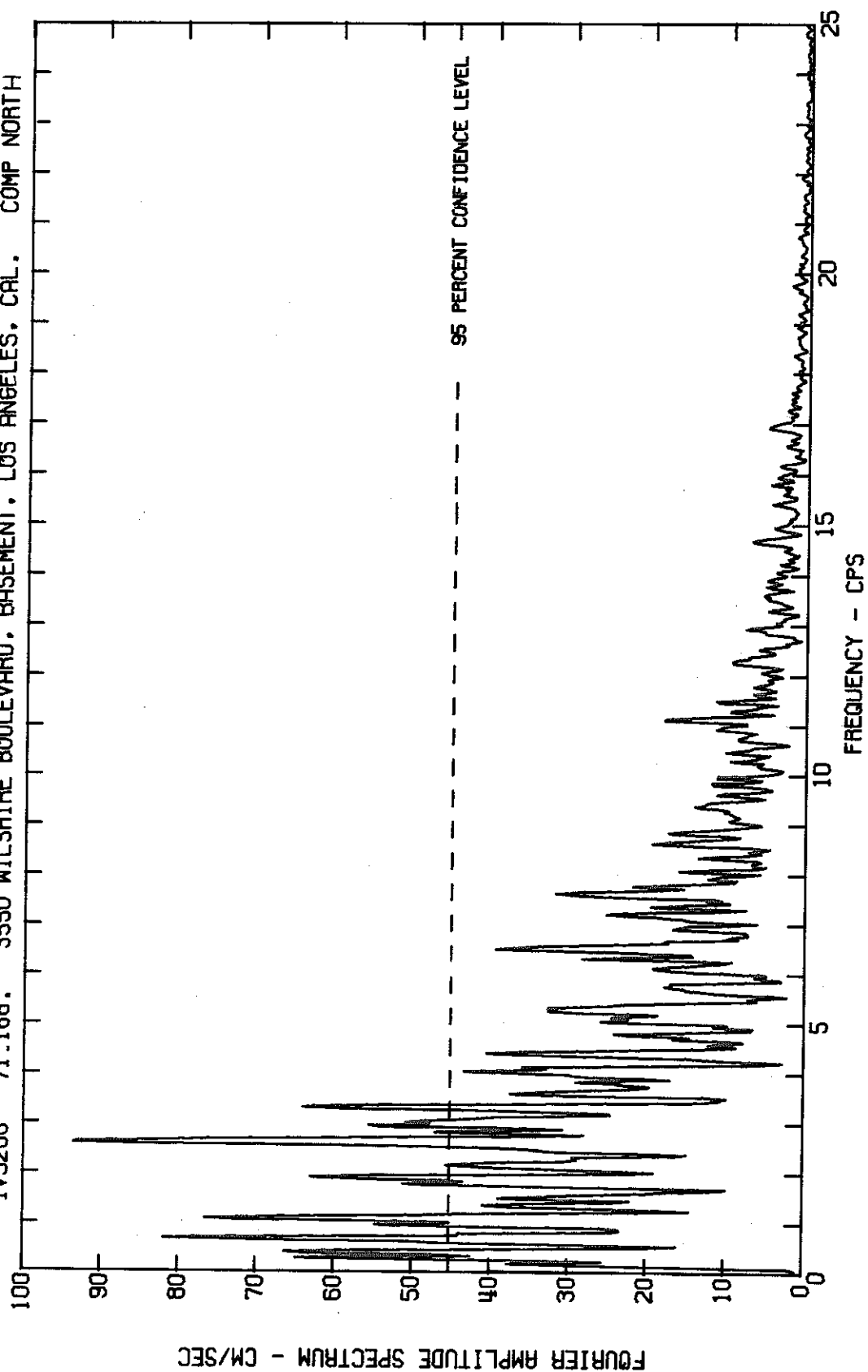


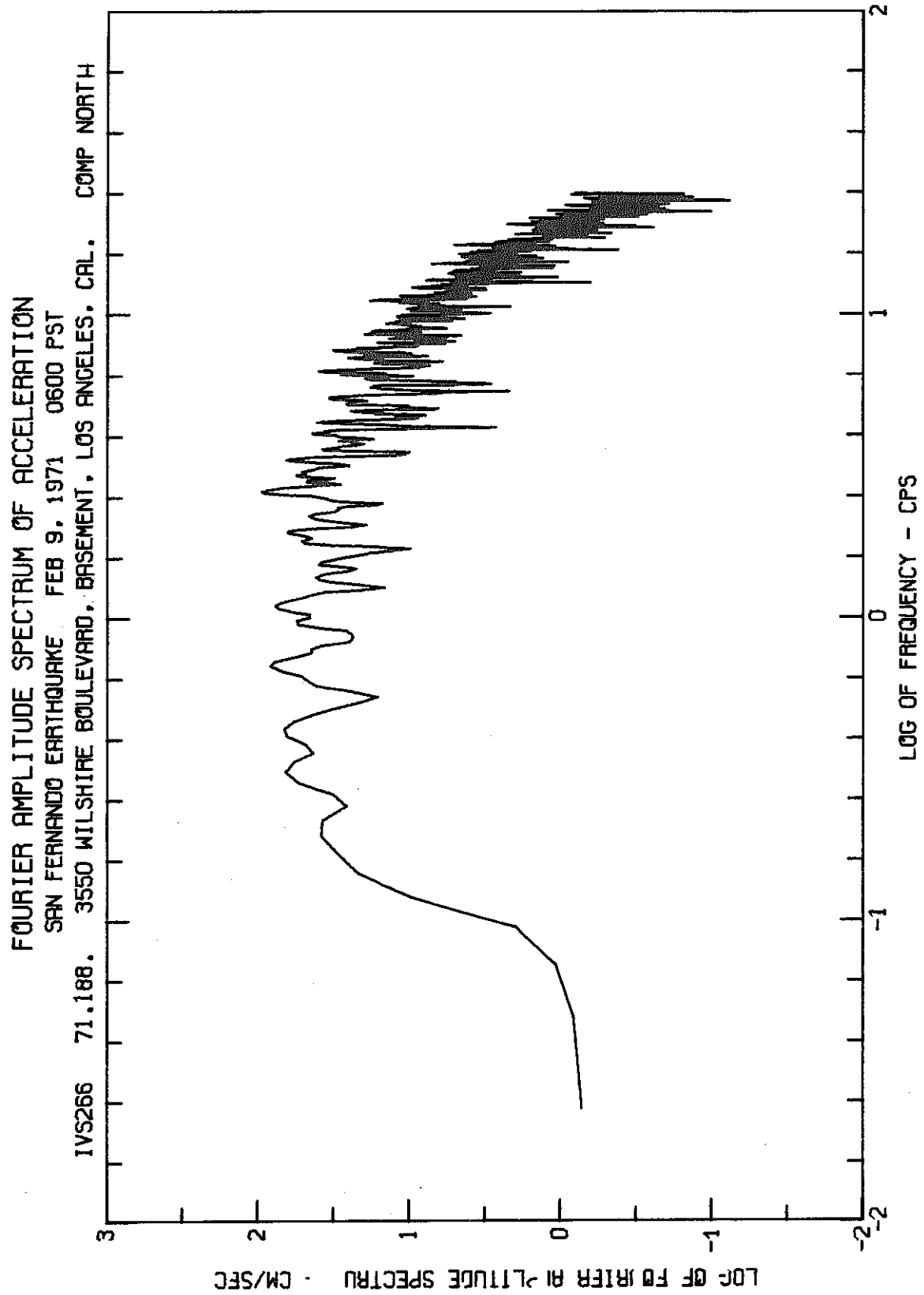


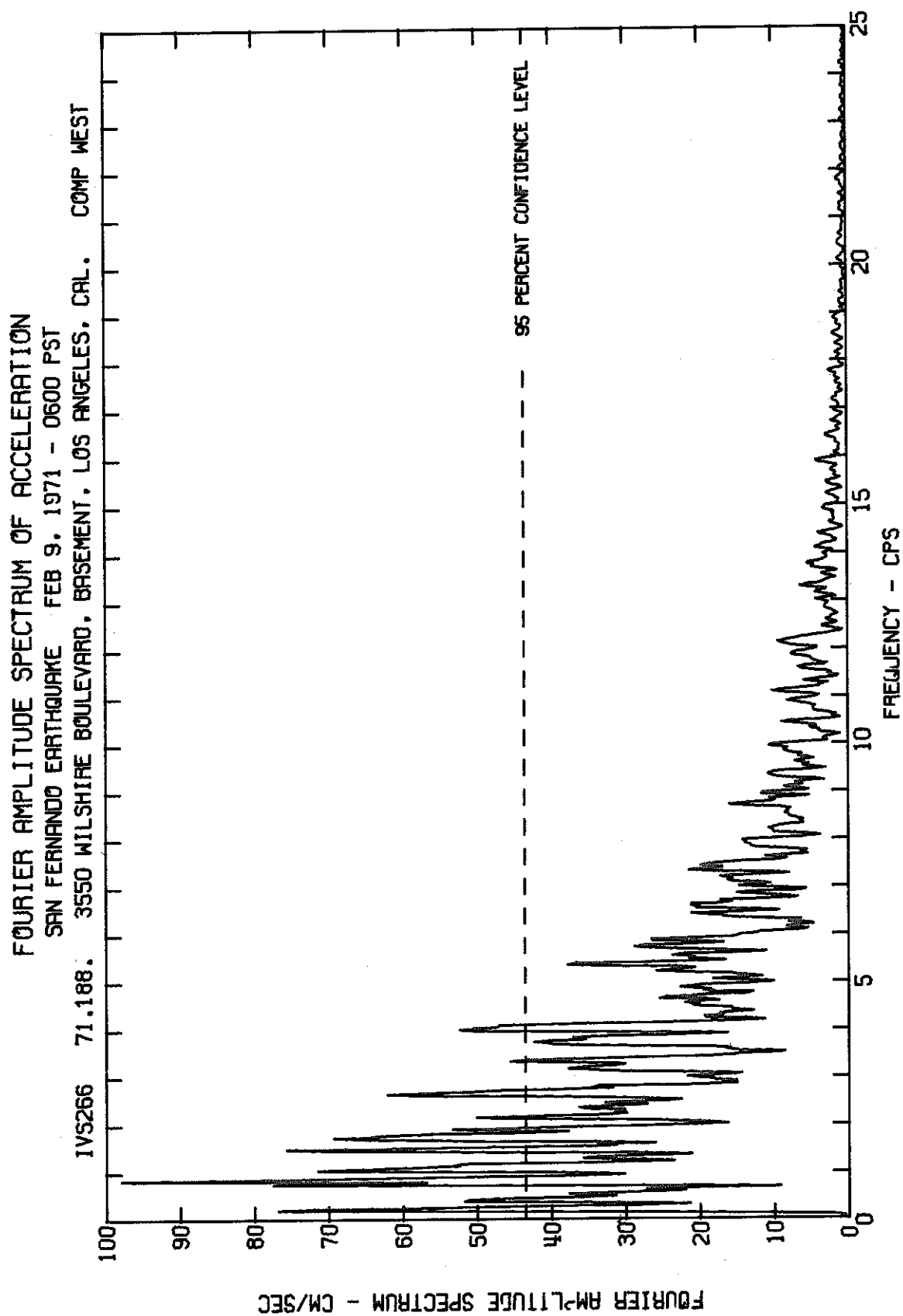
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

SAN FERNANDO EARTHQUAKE FEB 9, 1971 0600 PST

IVS266 71.188. 3550 WILSHIRE BOULEVARD, BASEMENT, LOS ANGELES, CAL. COMP NORTH



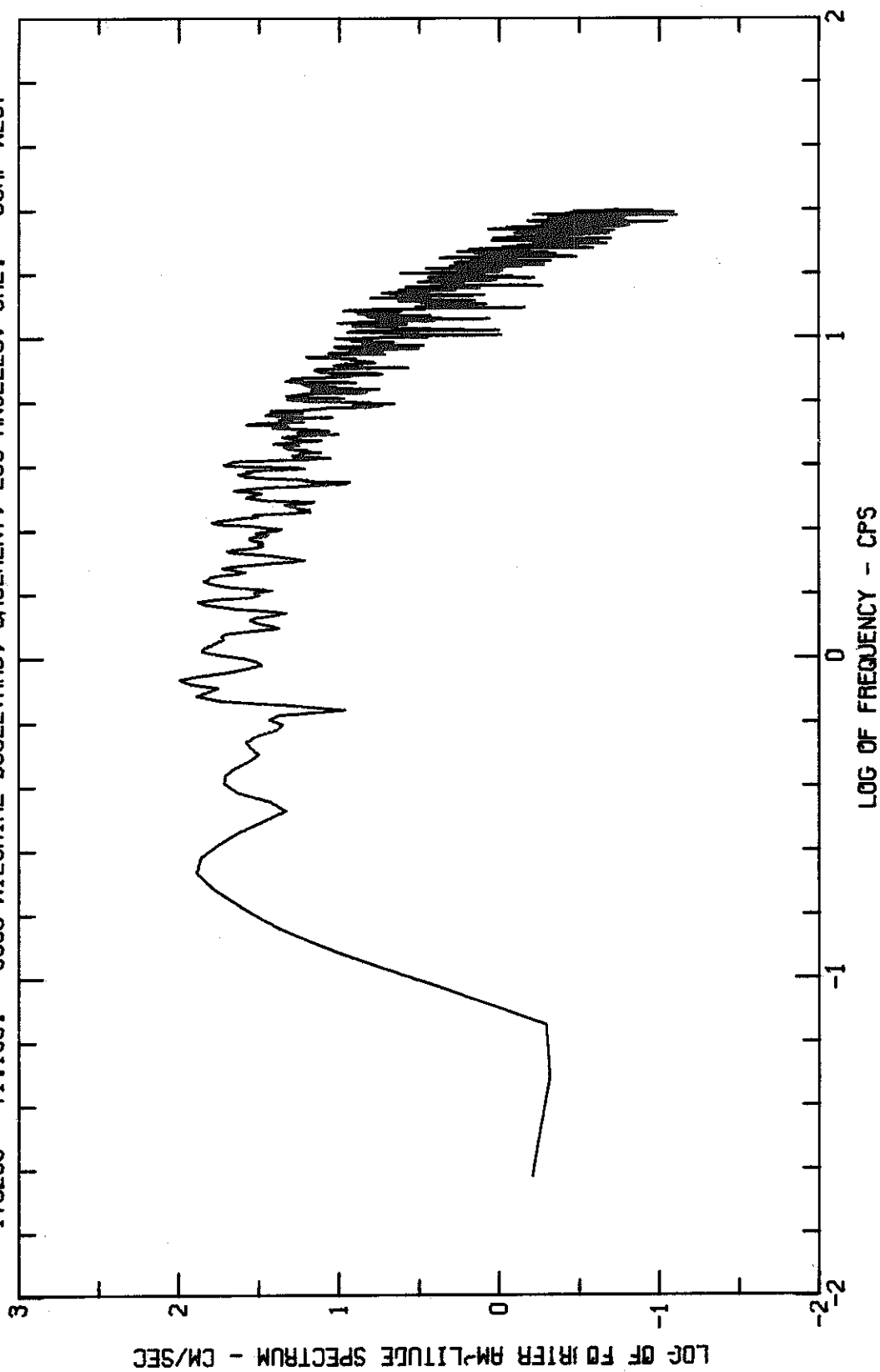


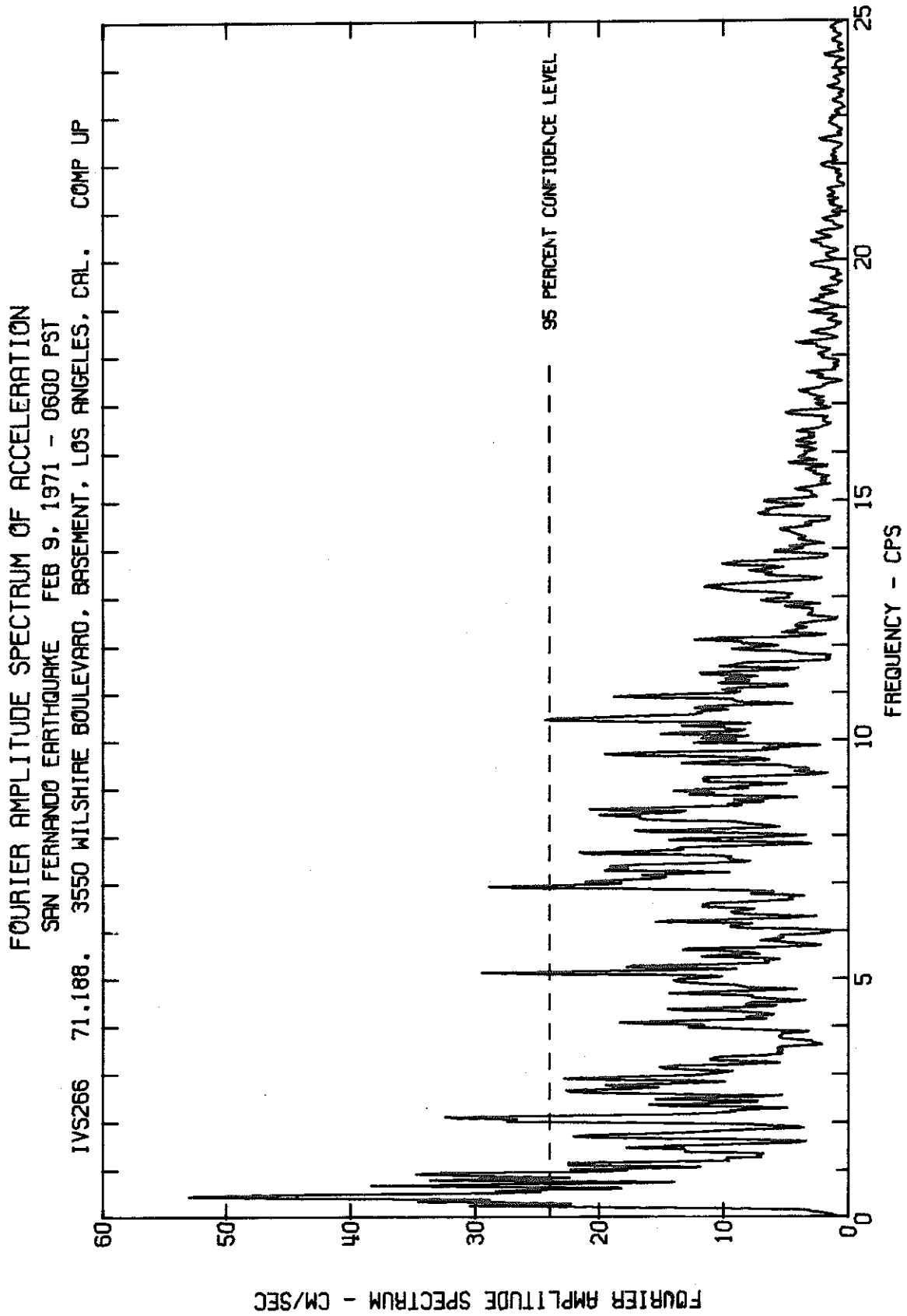


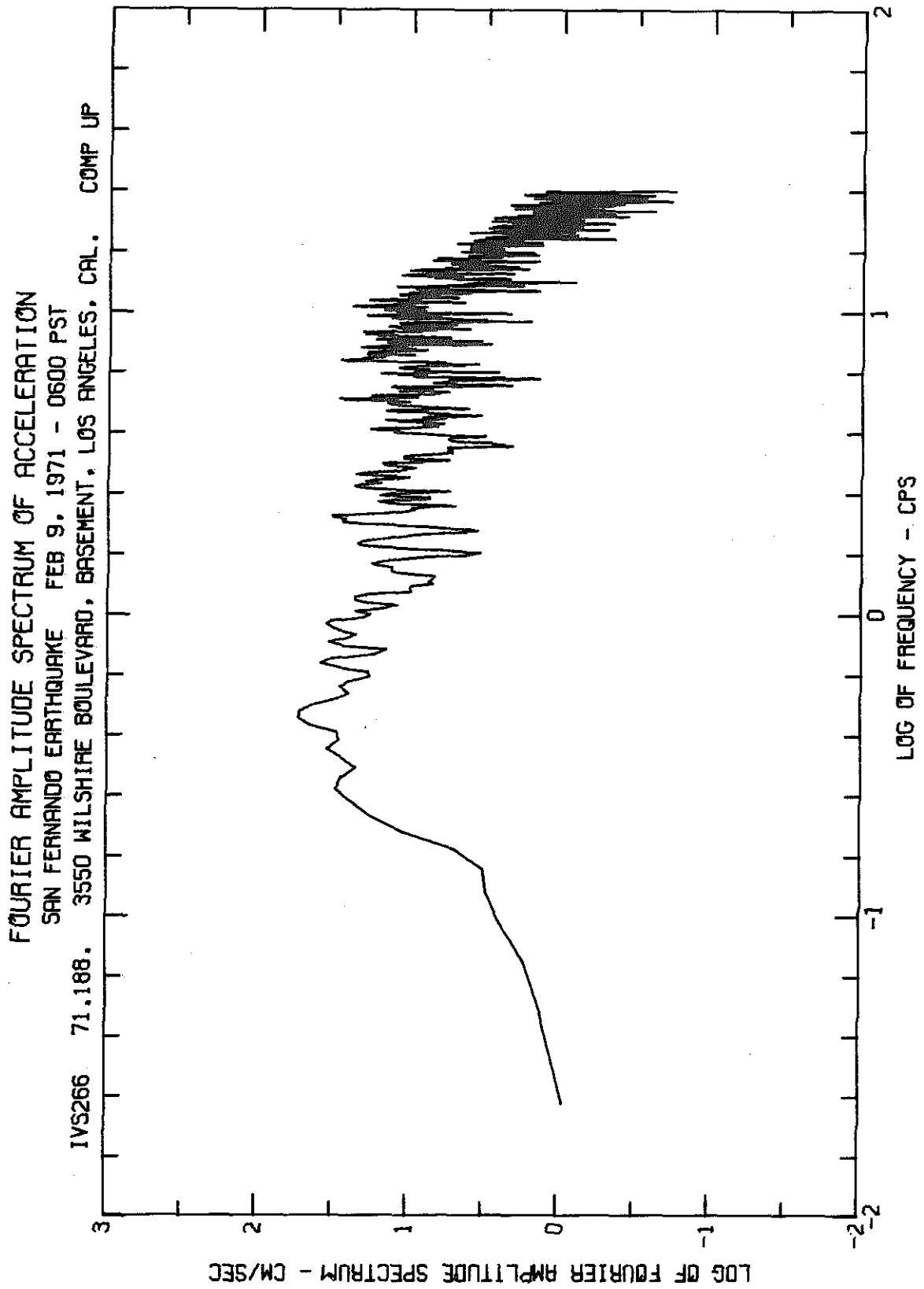
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

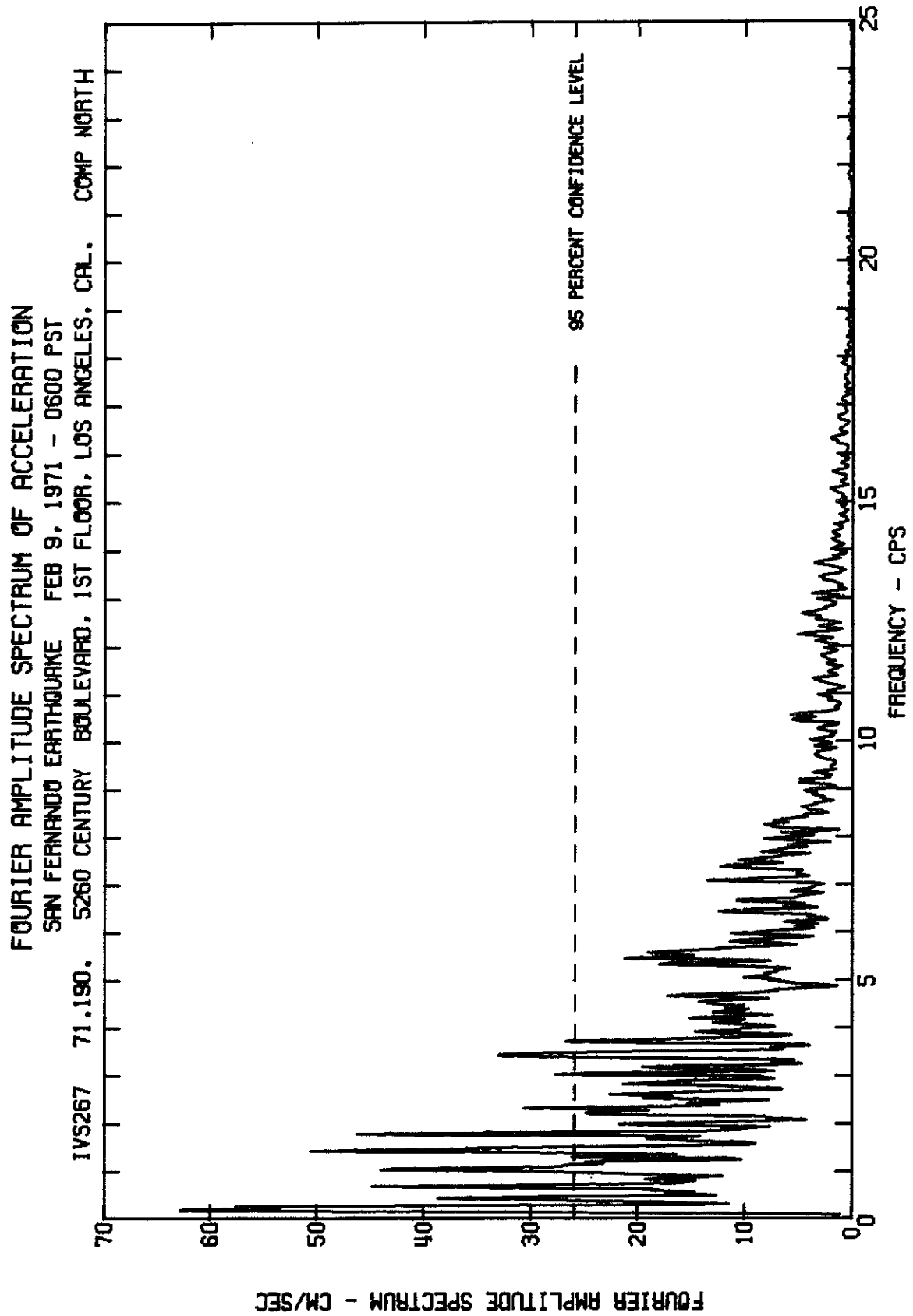
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

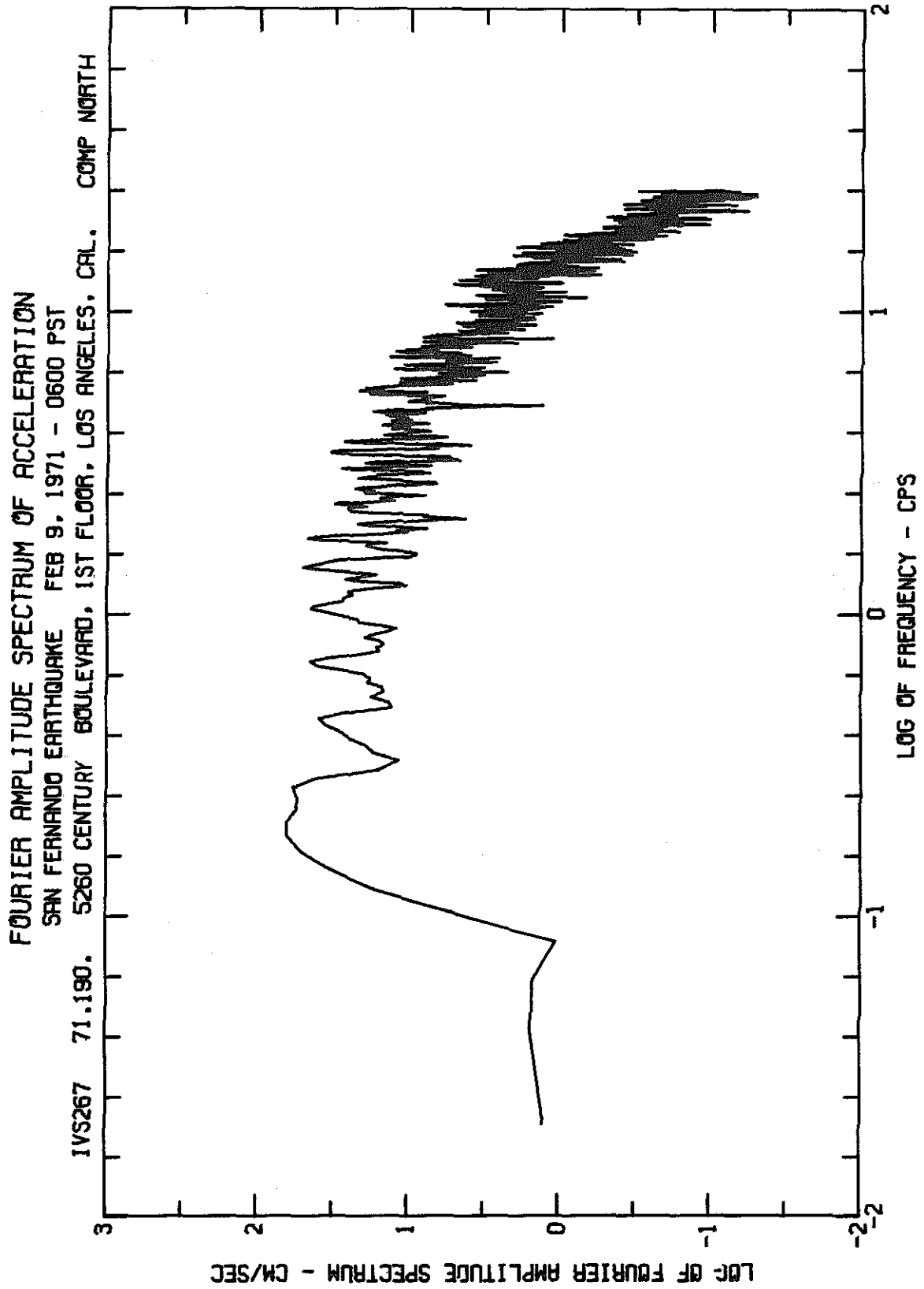
IVS266 71.188. 3550 WILSHIRE BOULEVARD, BASEMENT, LOS ANGELES, CAL. COMP WEST

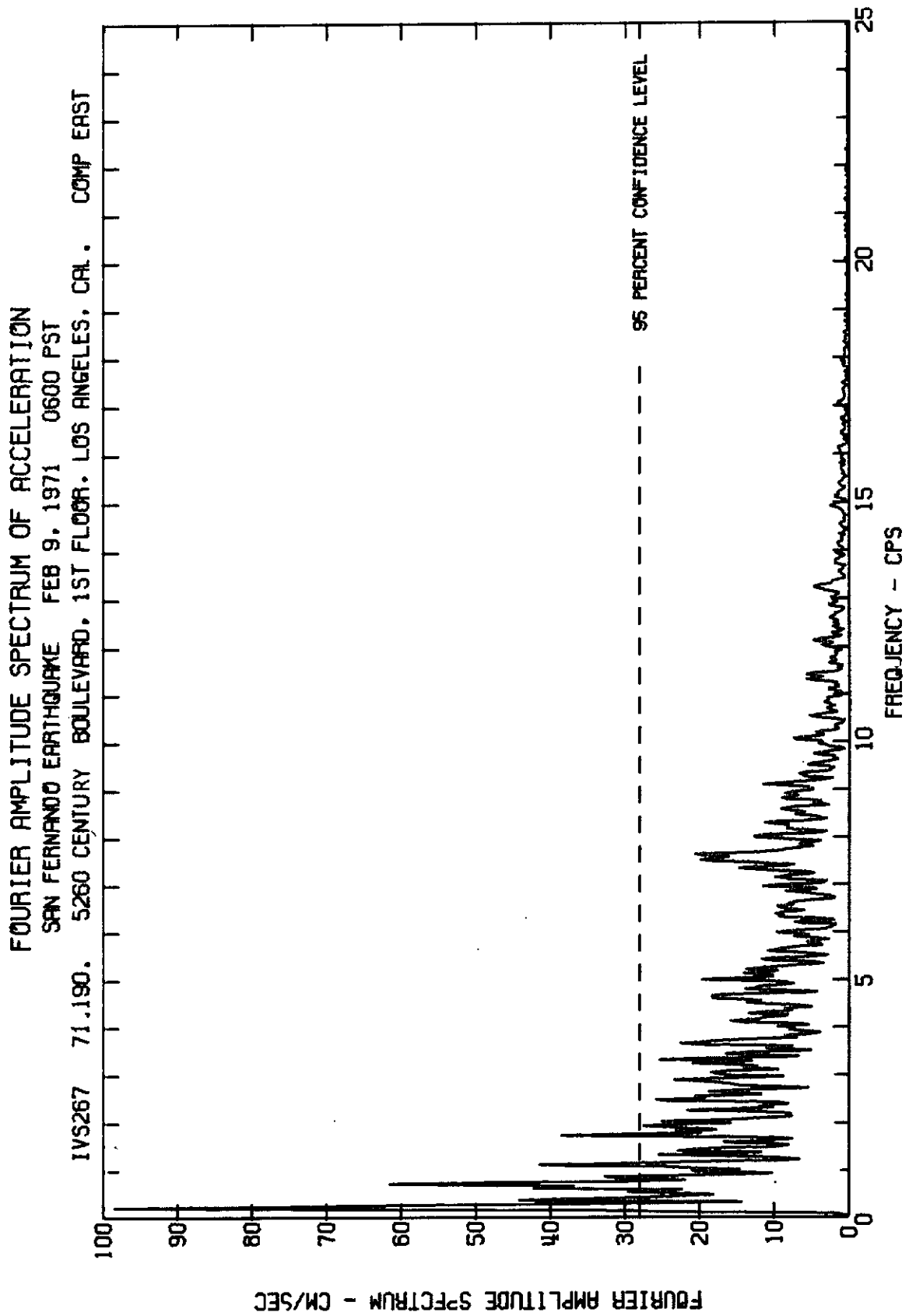


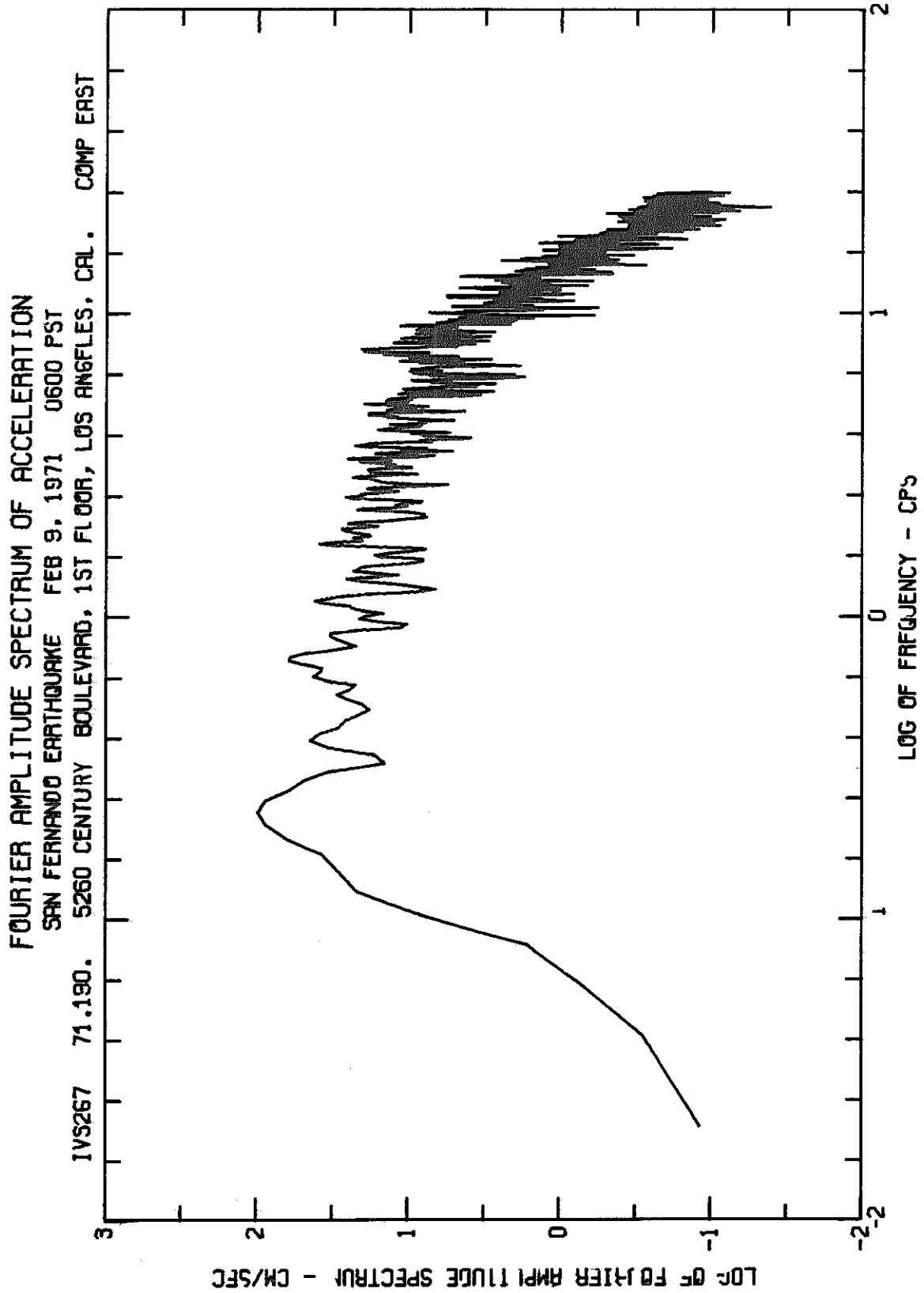


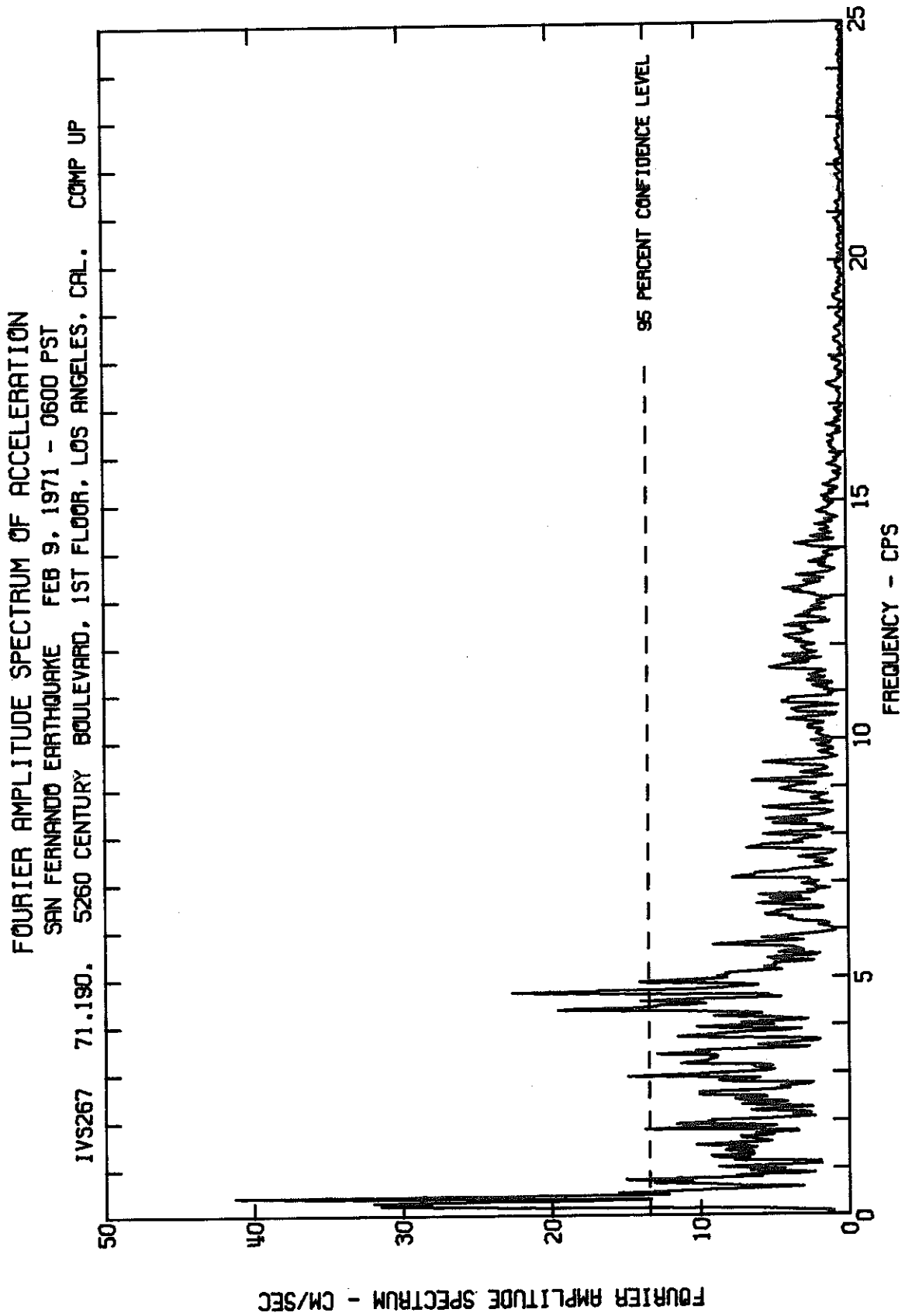


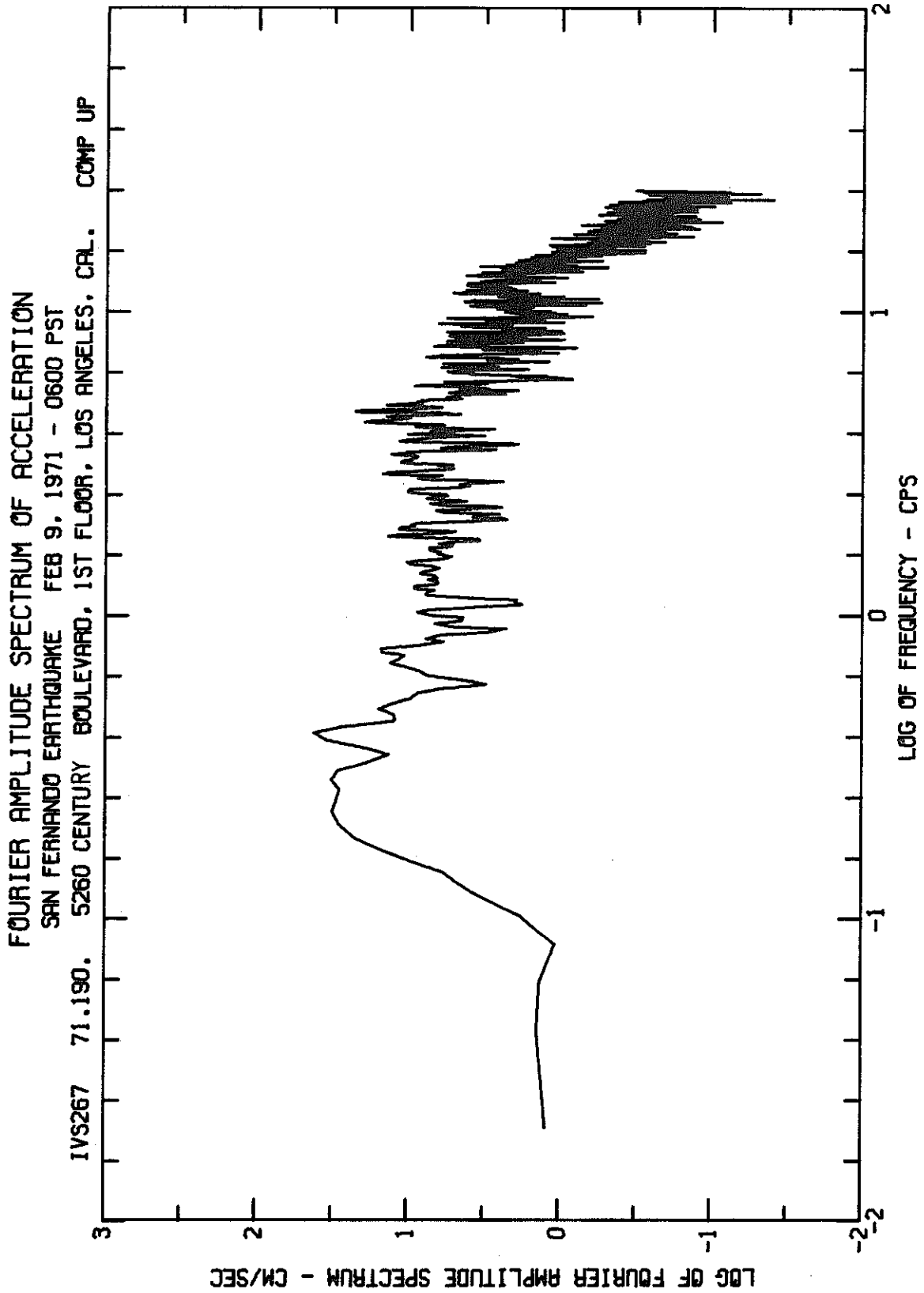


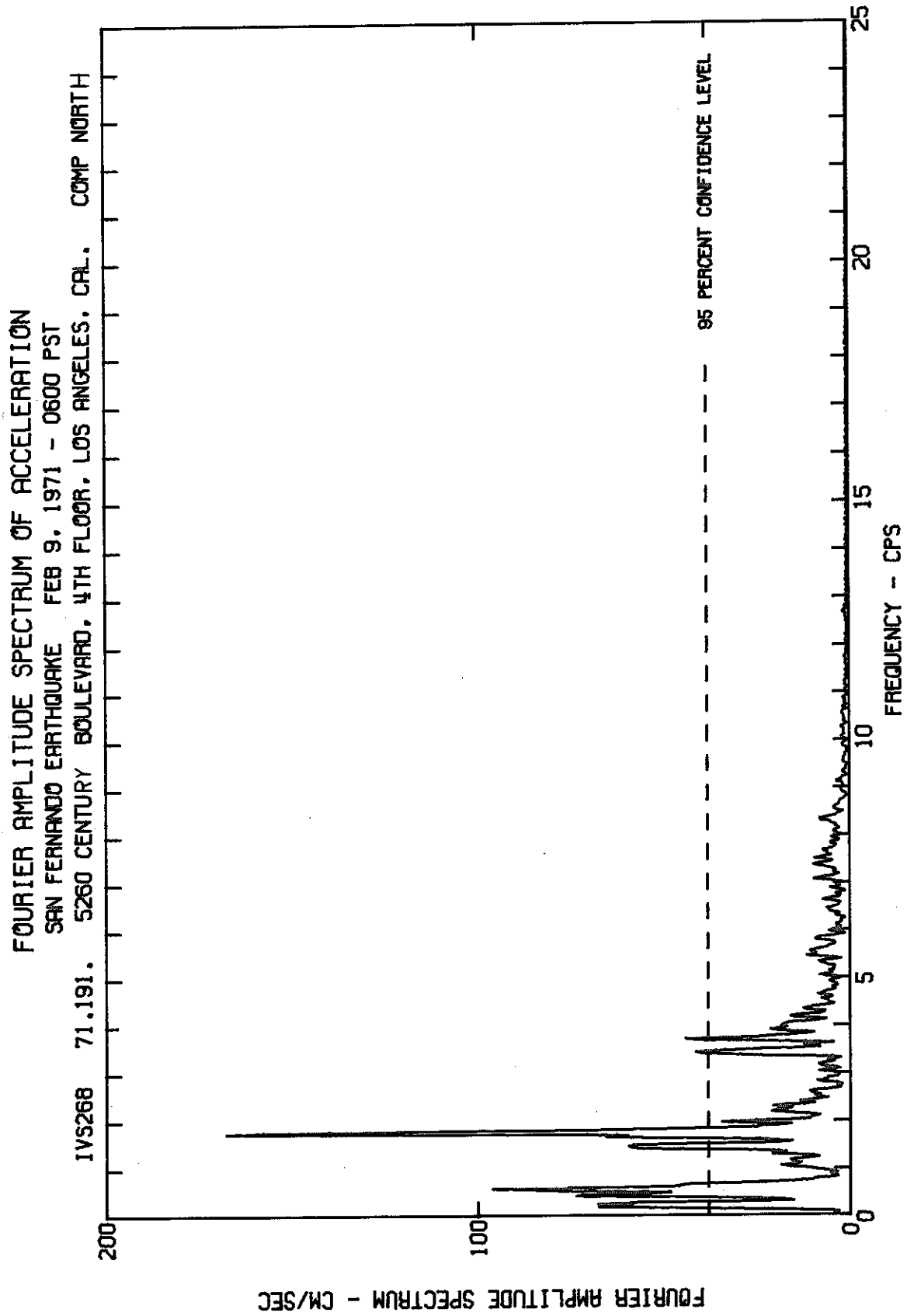


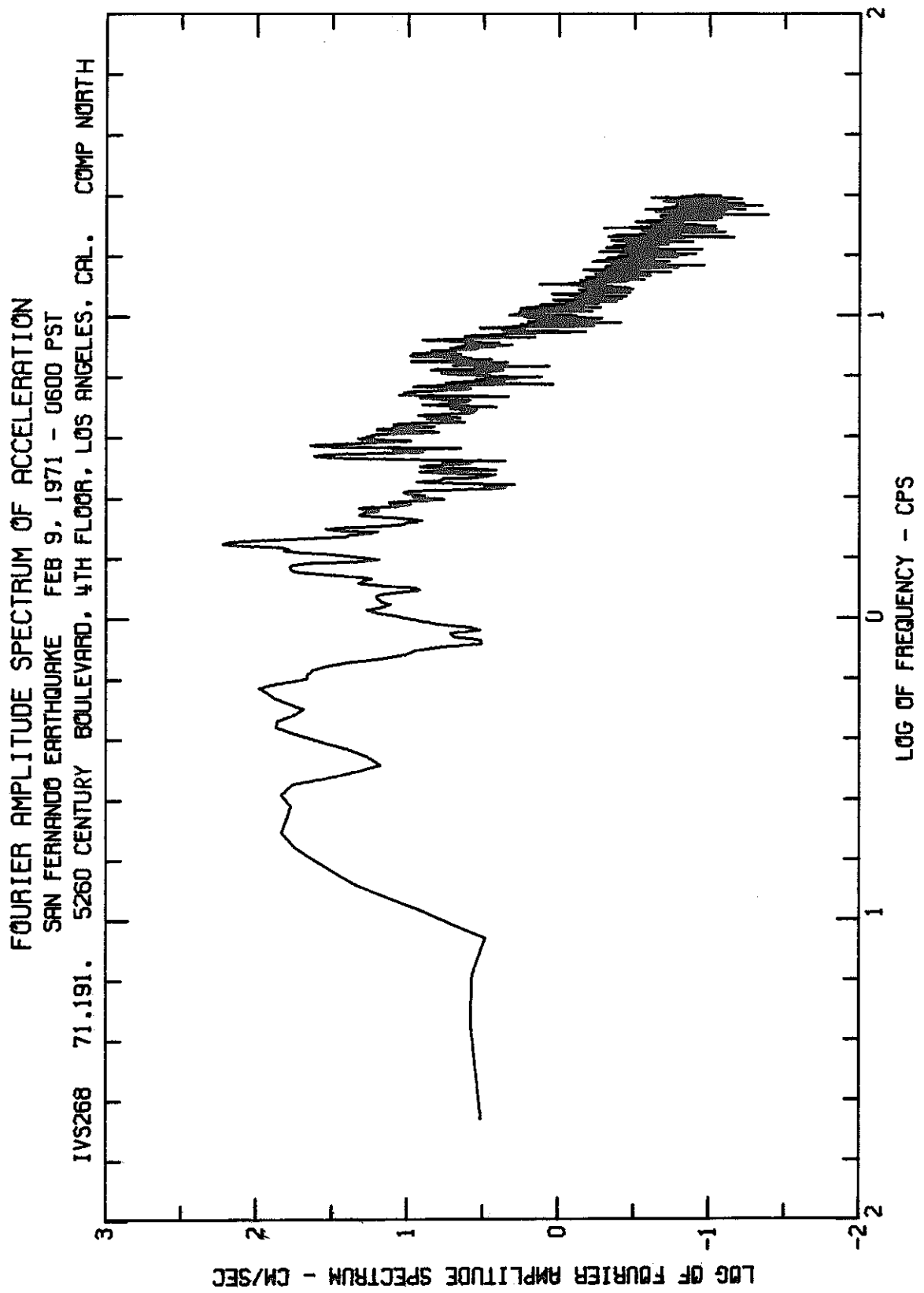


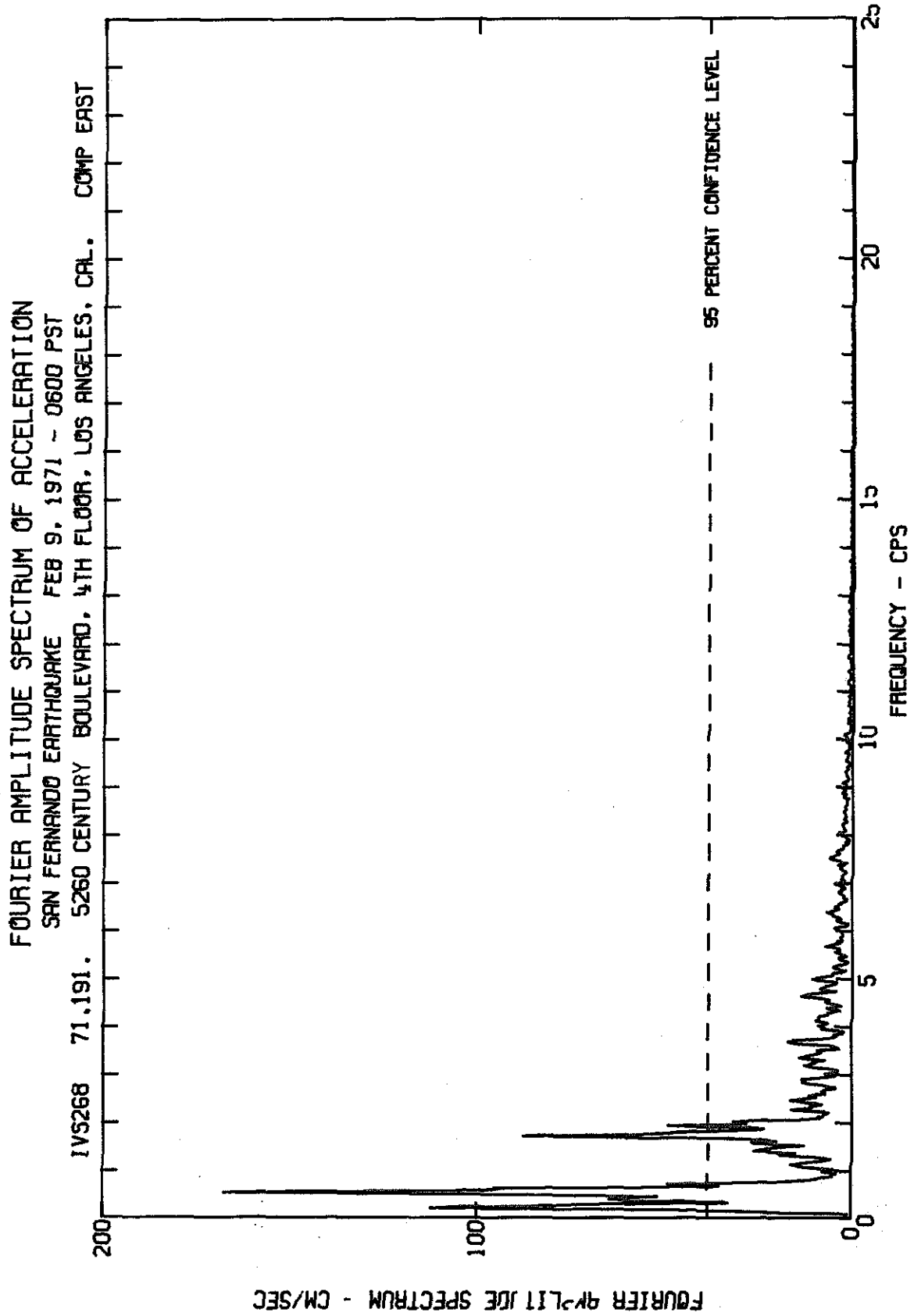


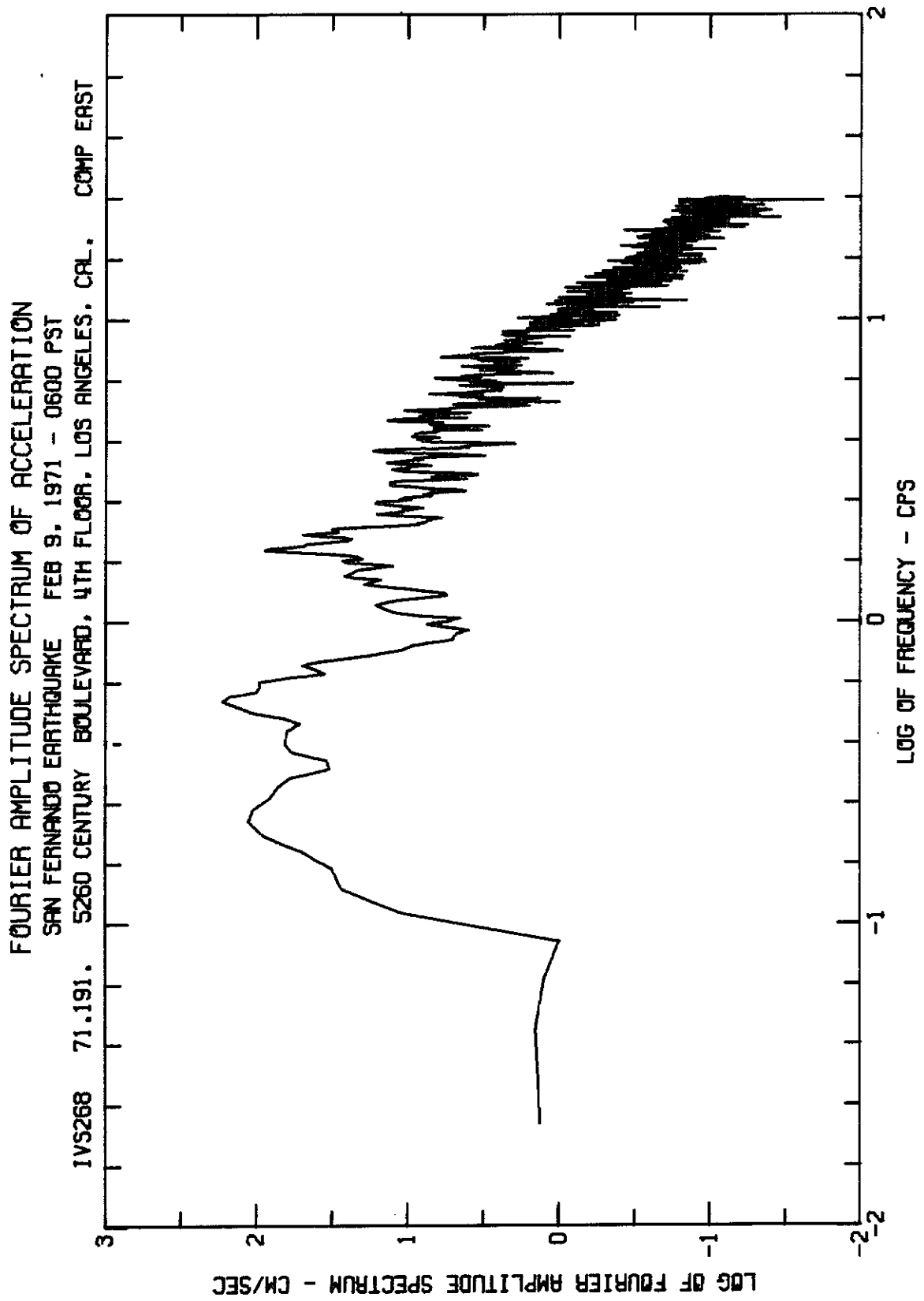


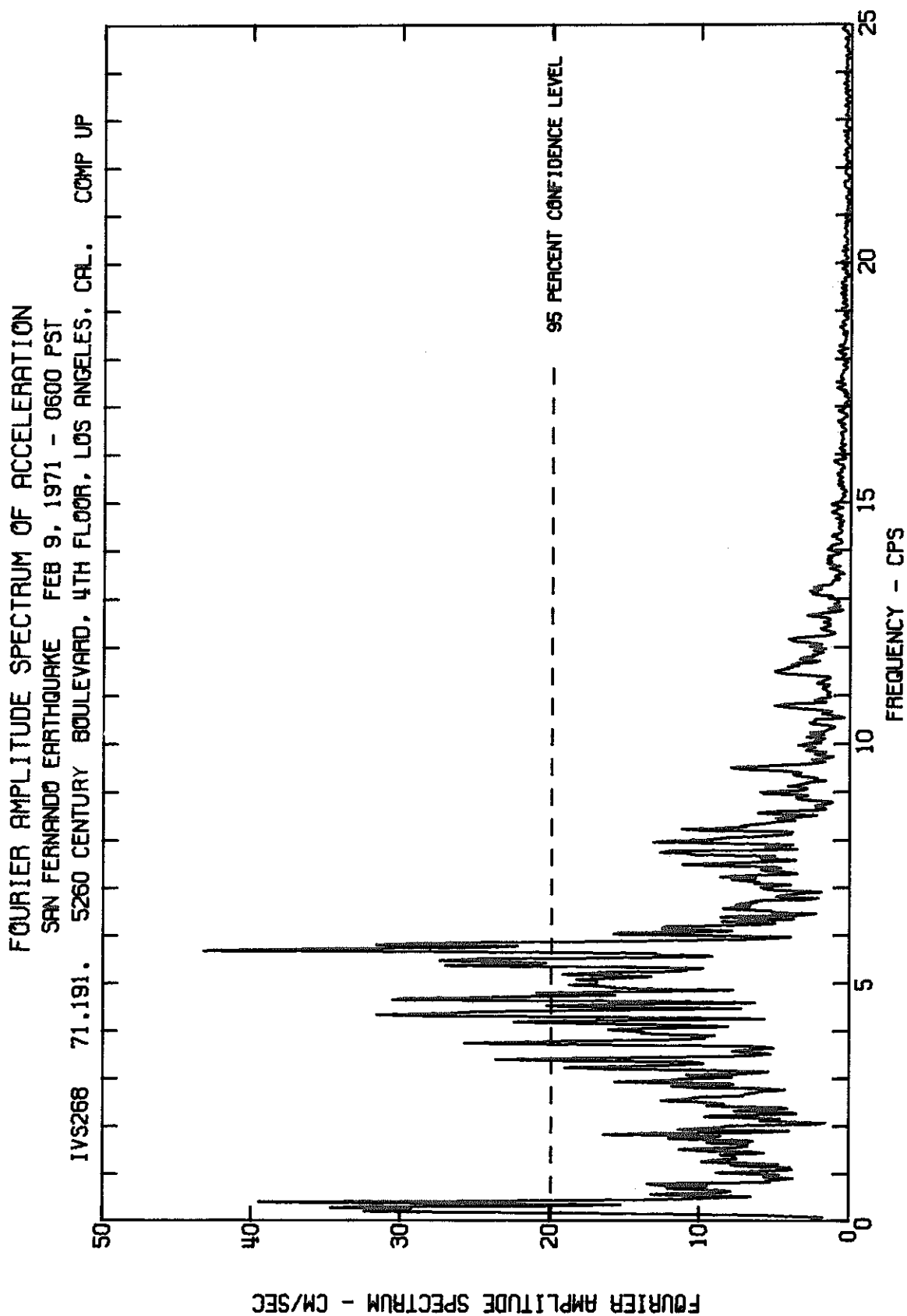


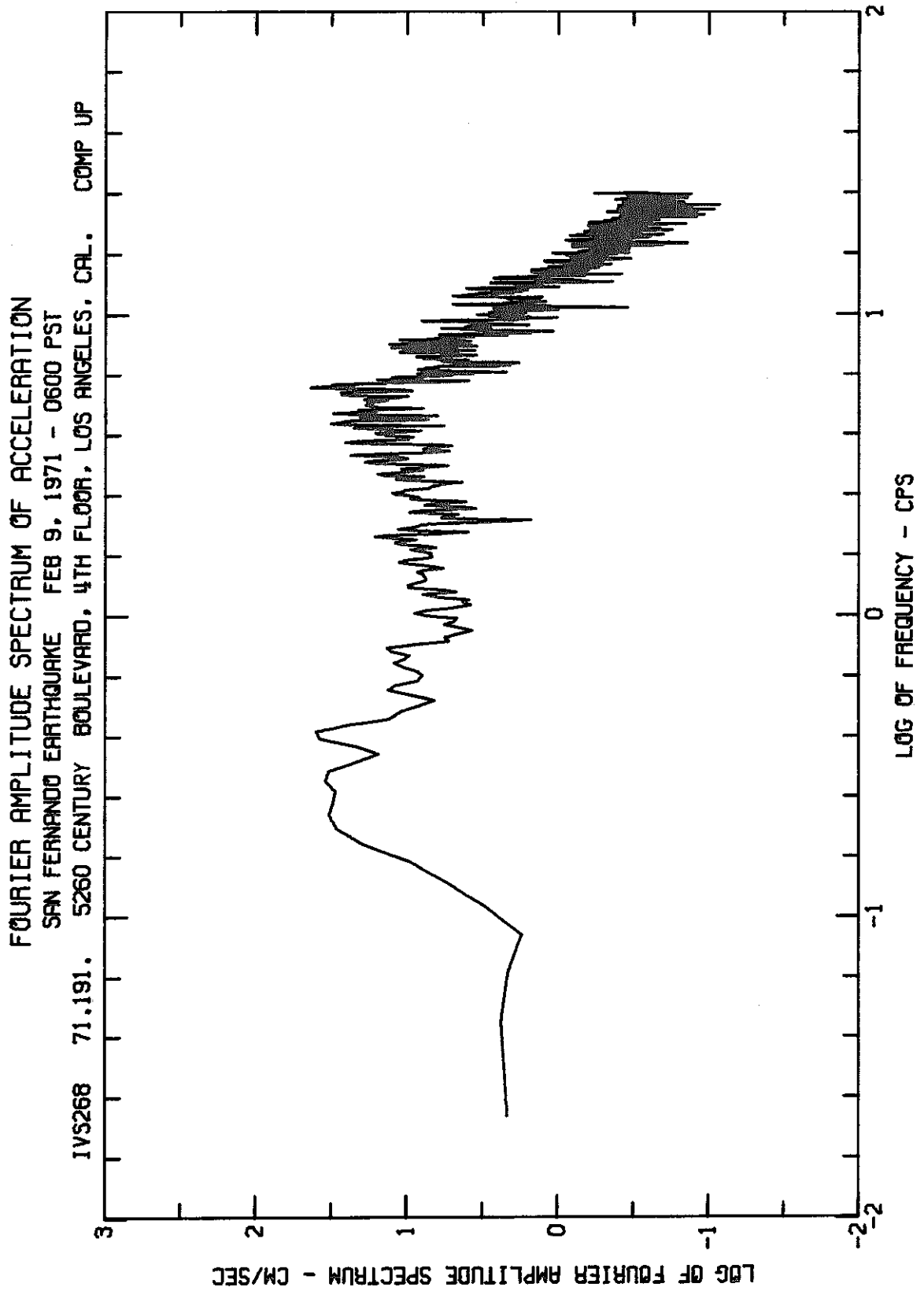


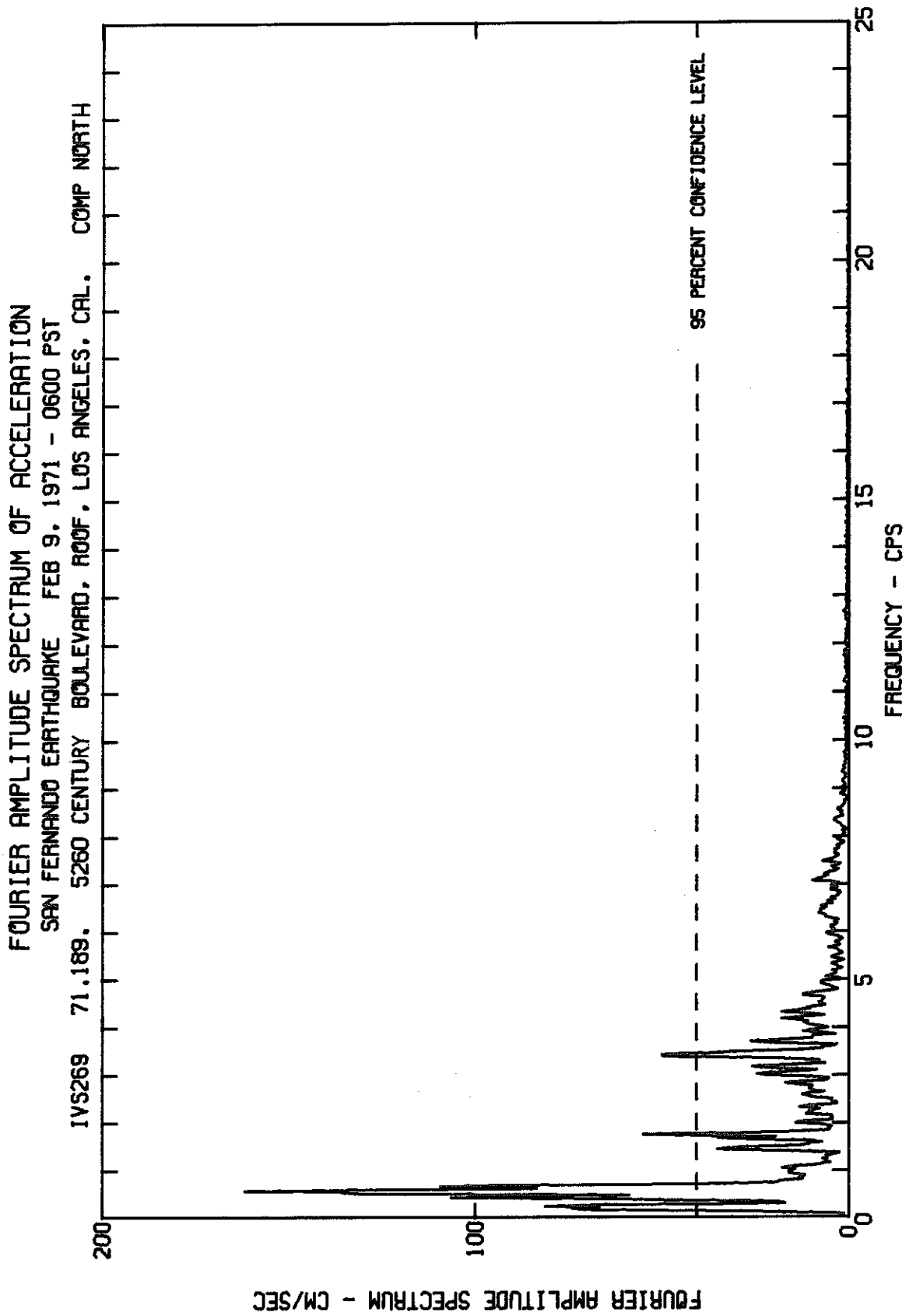


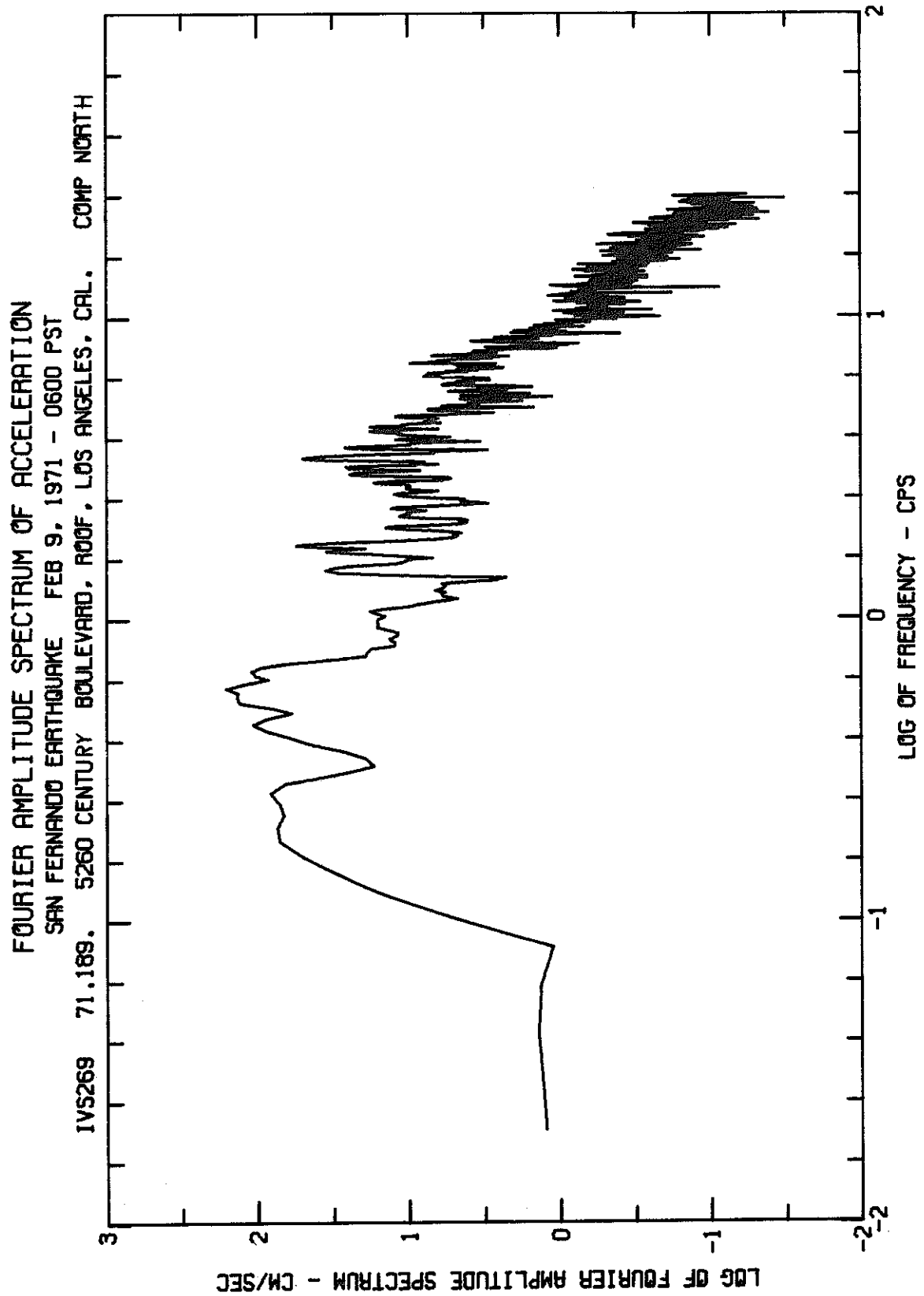


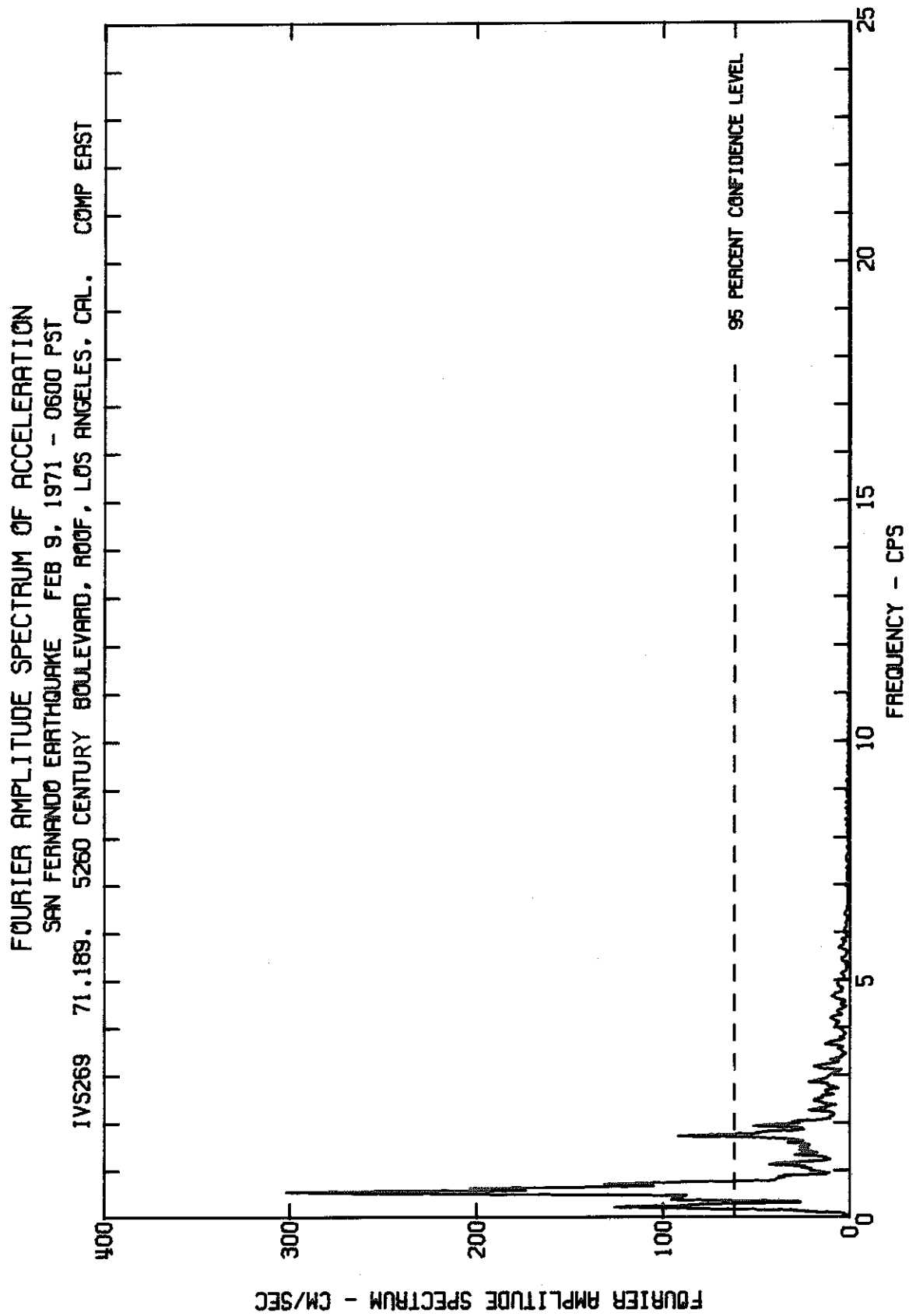


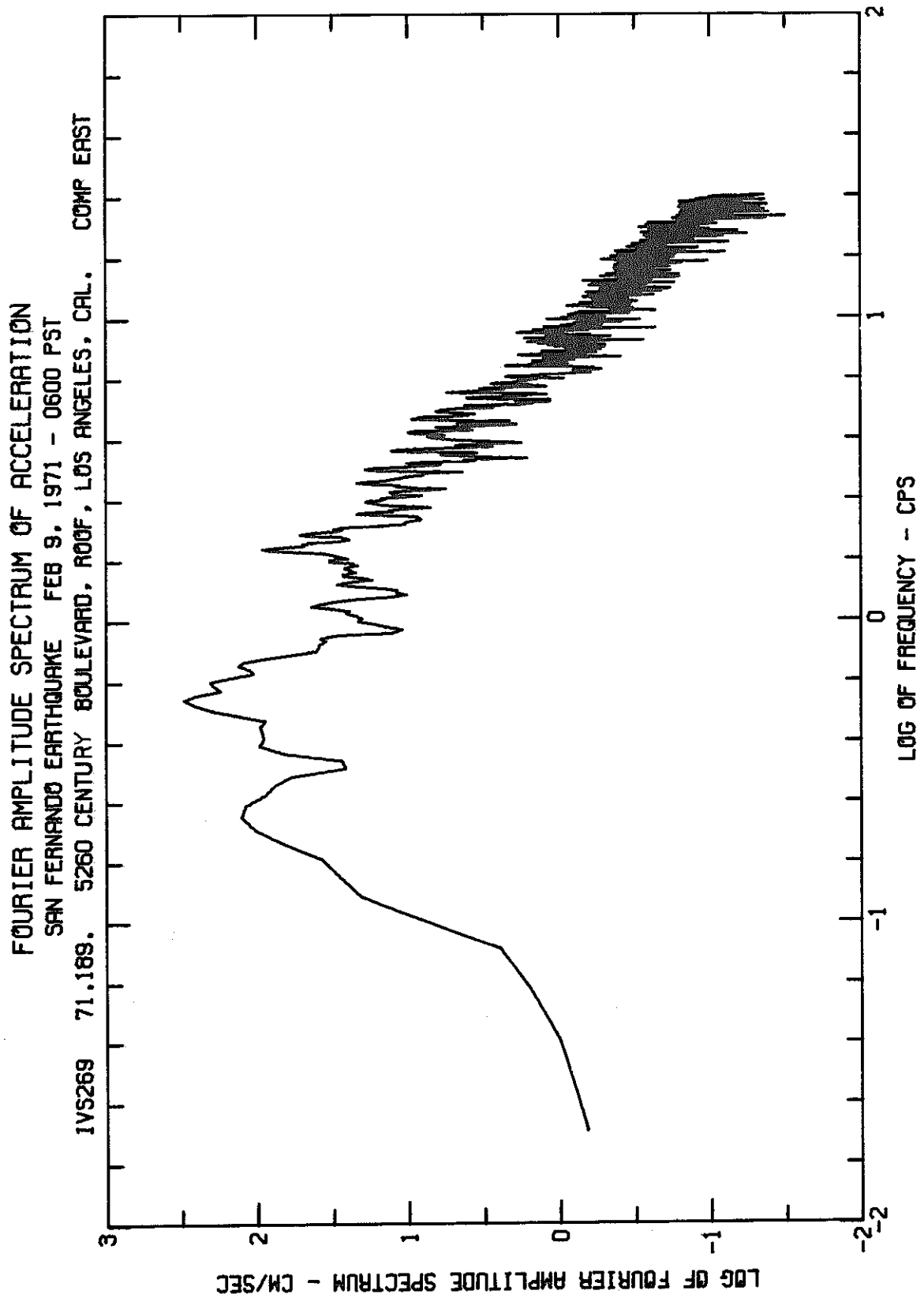




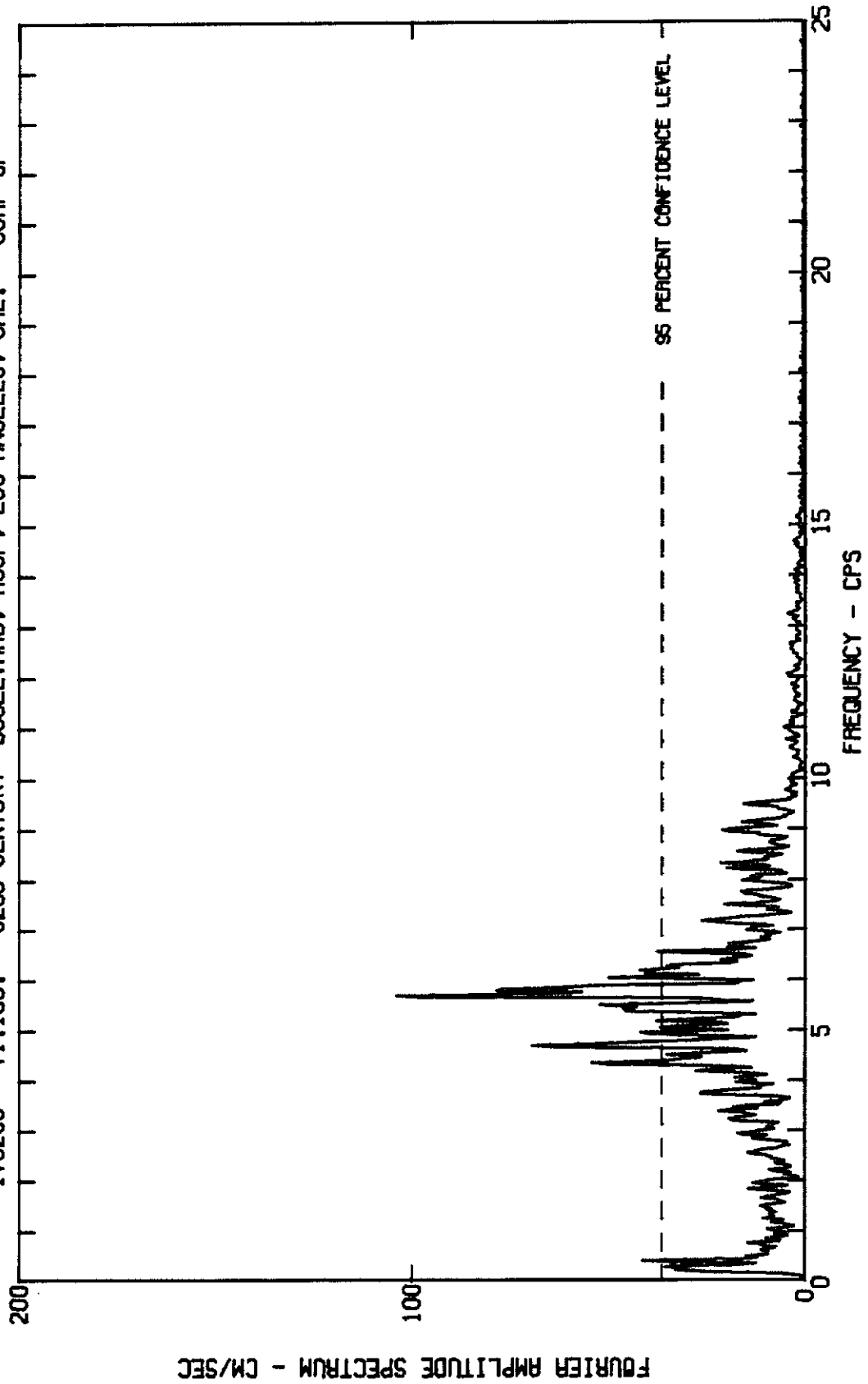


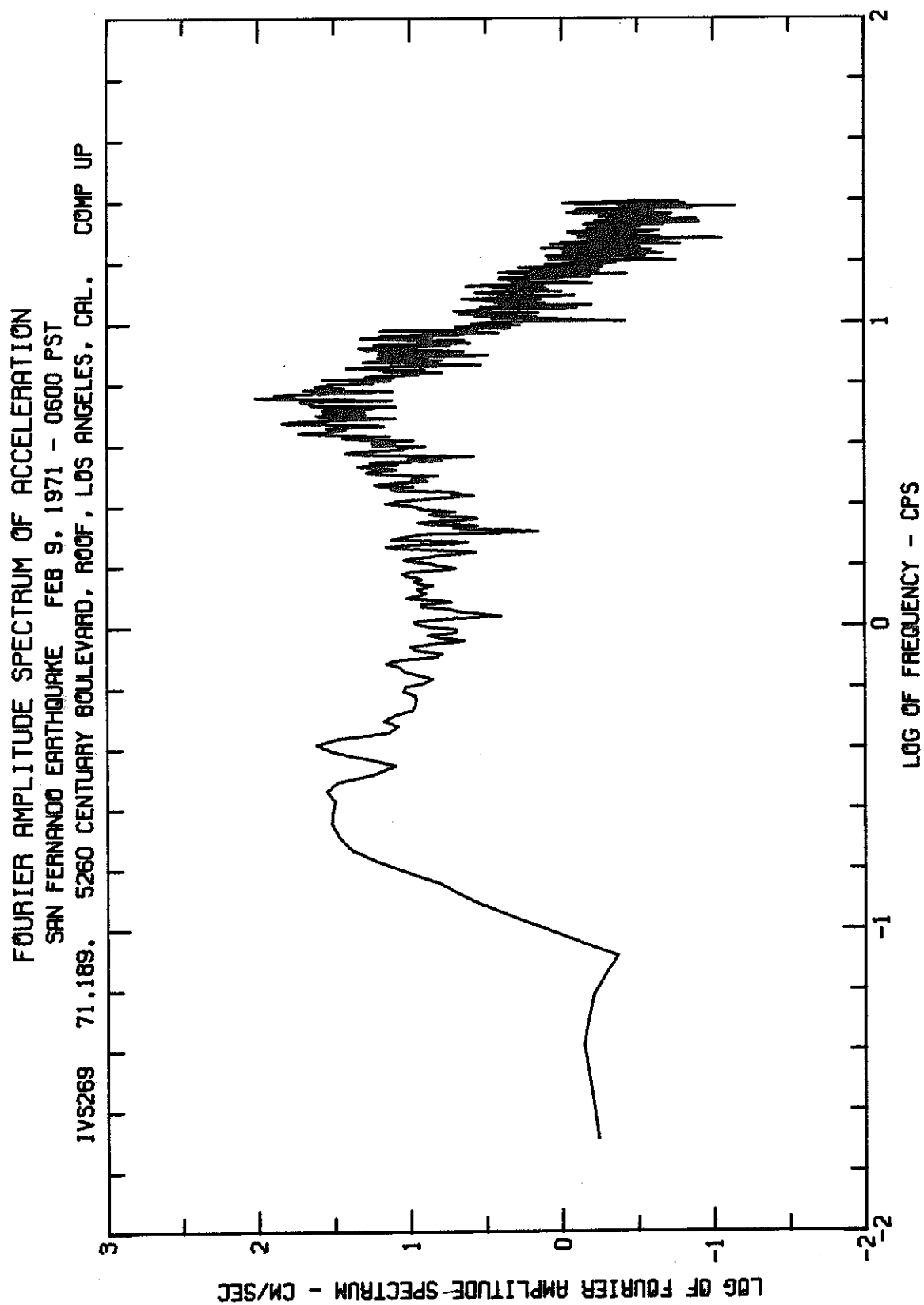


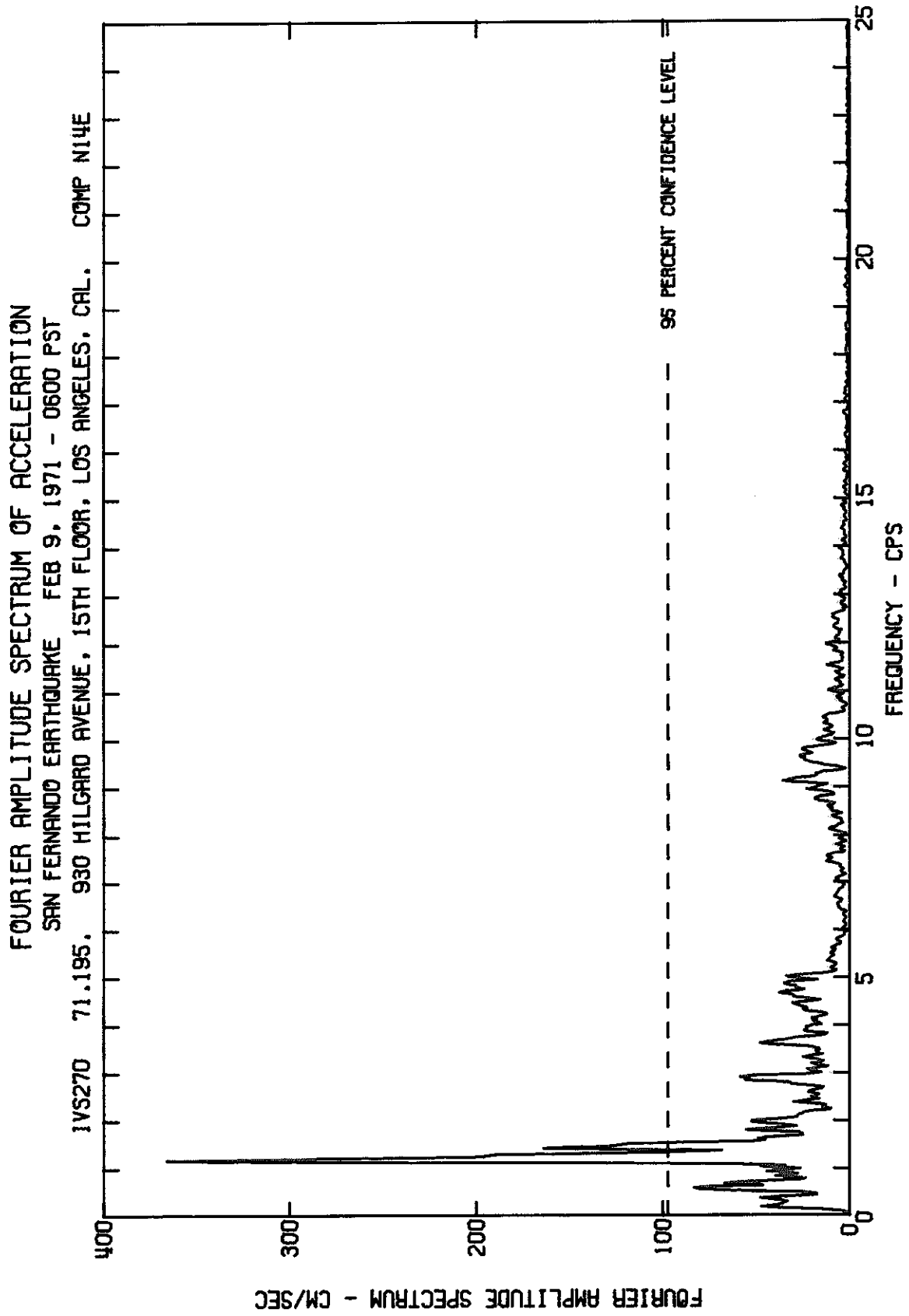




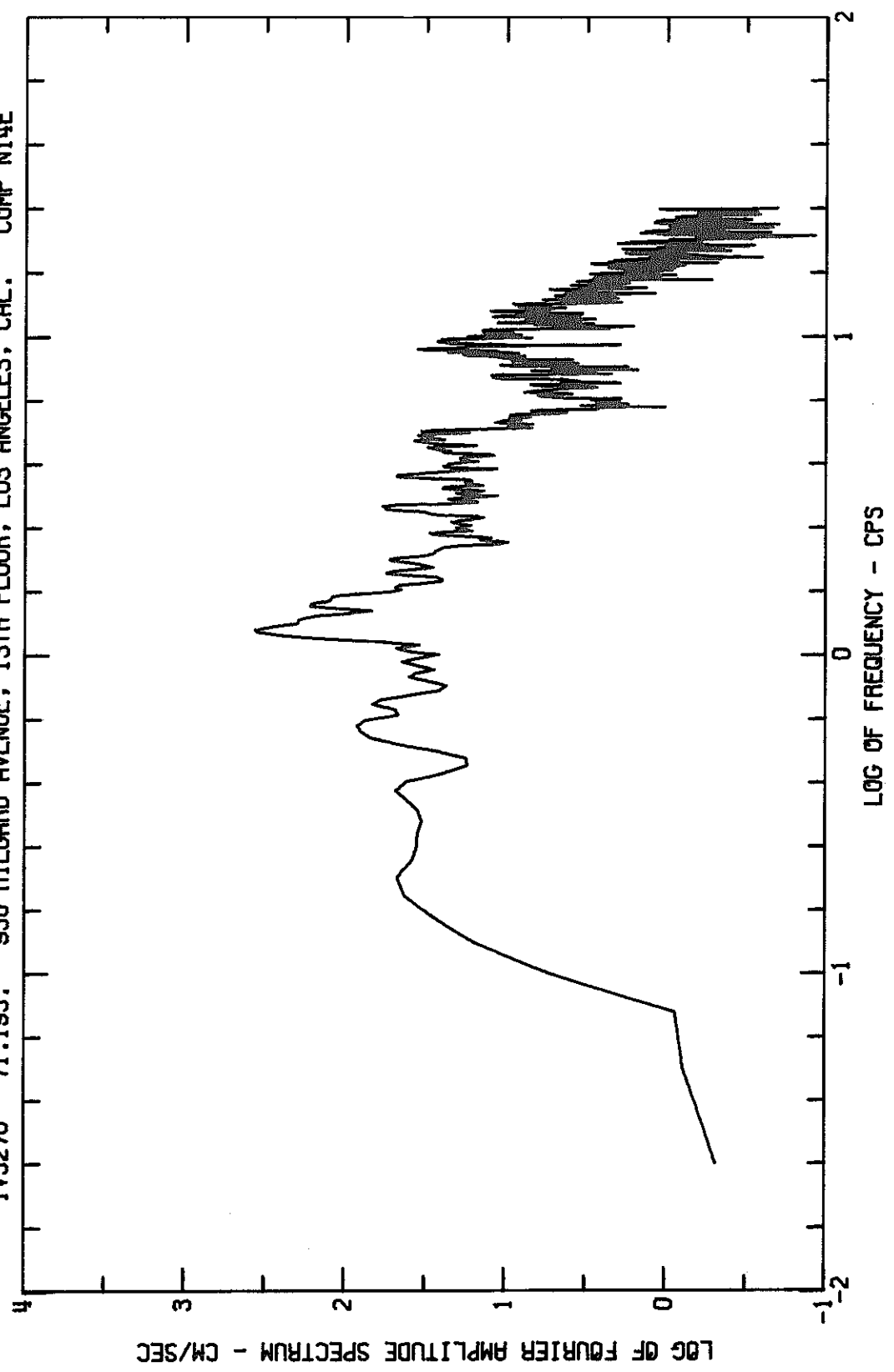
IVS269 71.189. 5260 CENTURY BOULEVARD, ROOF, LOS ANGELES, CAL. COMP UP
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

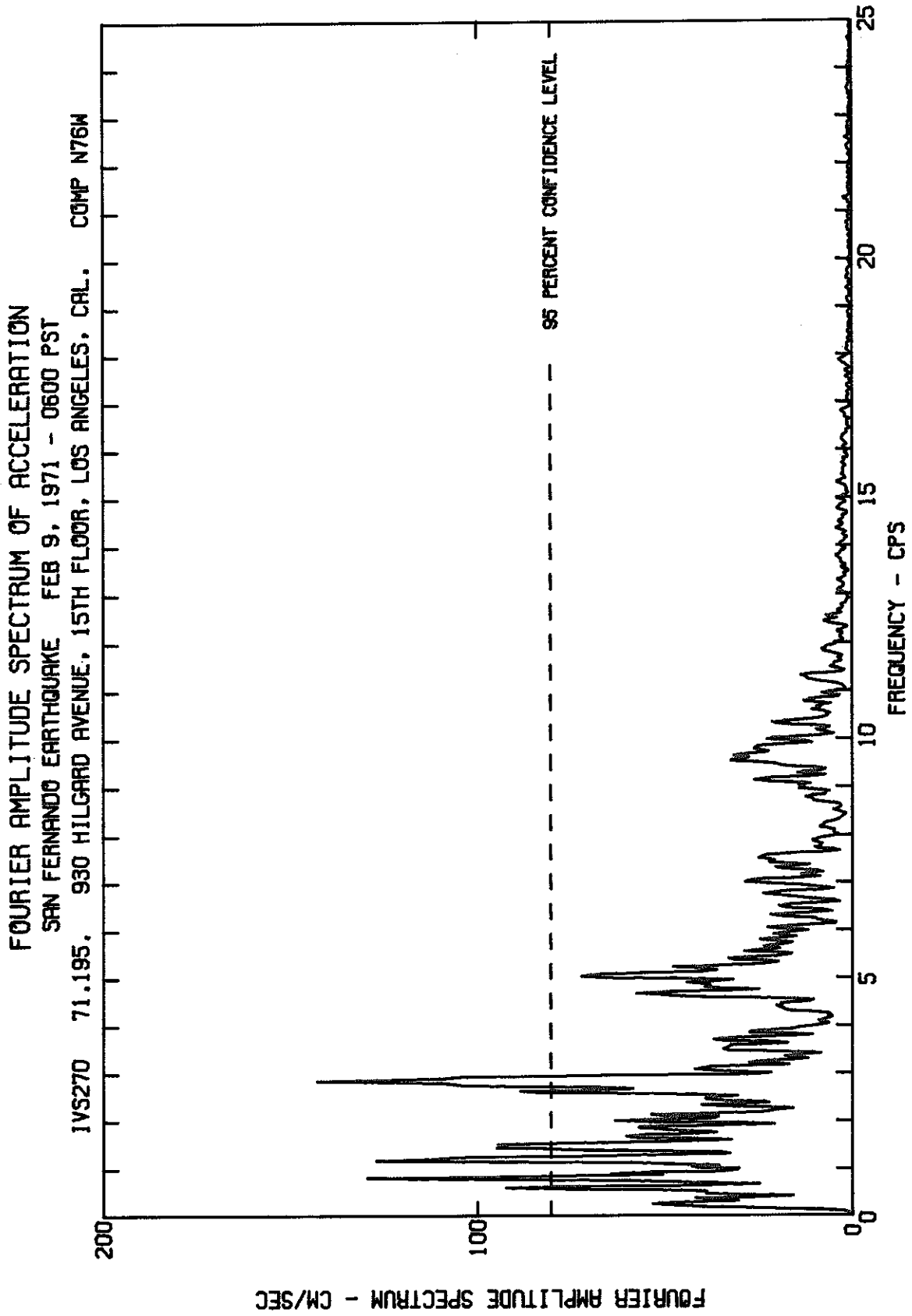


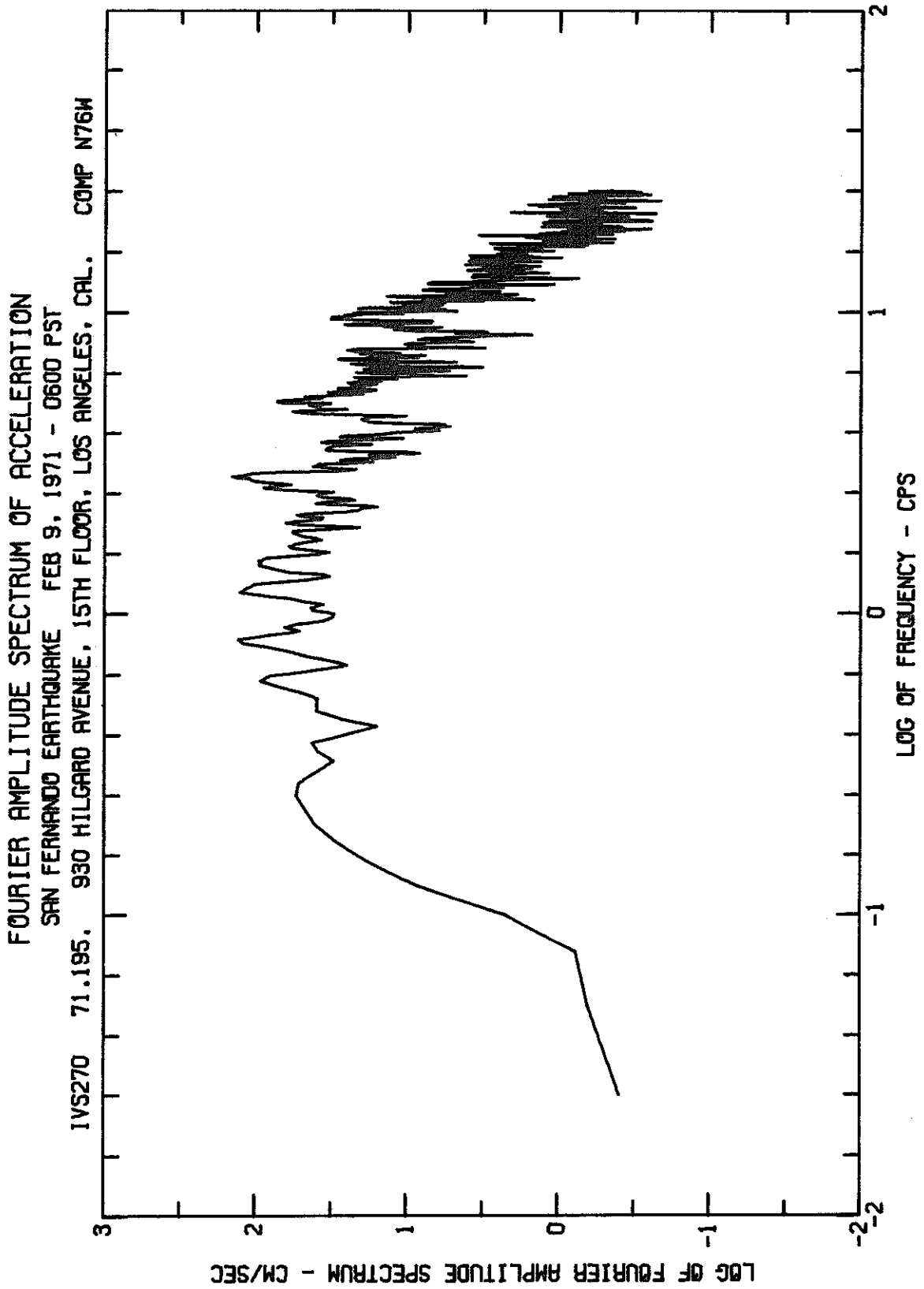


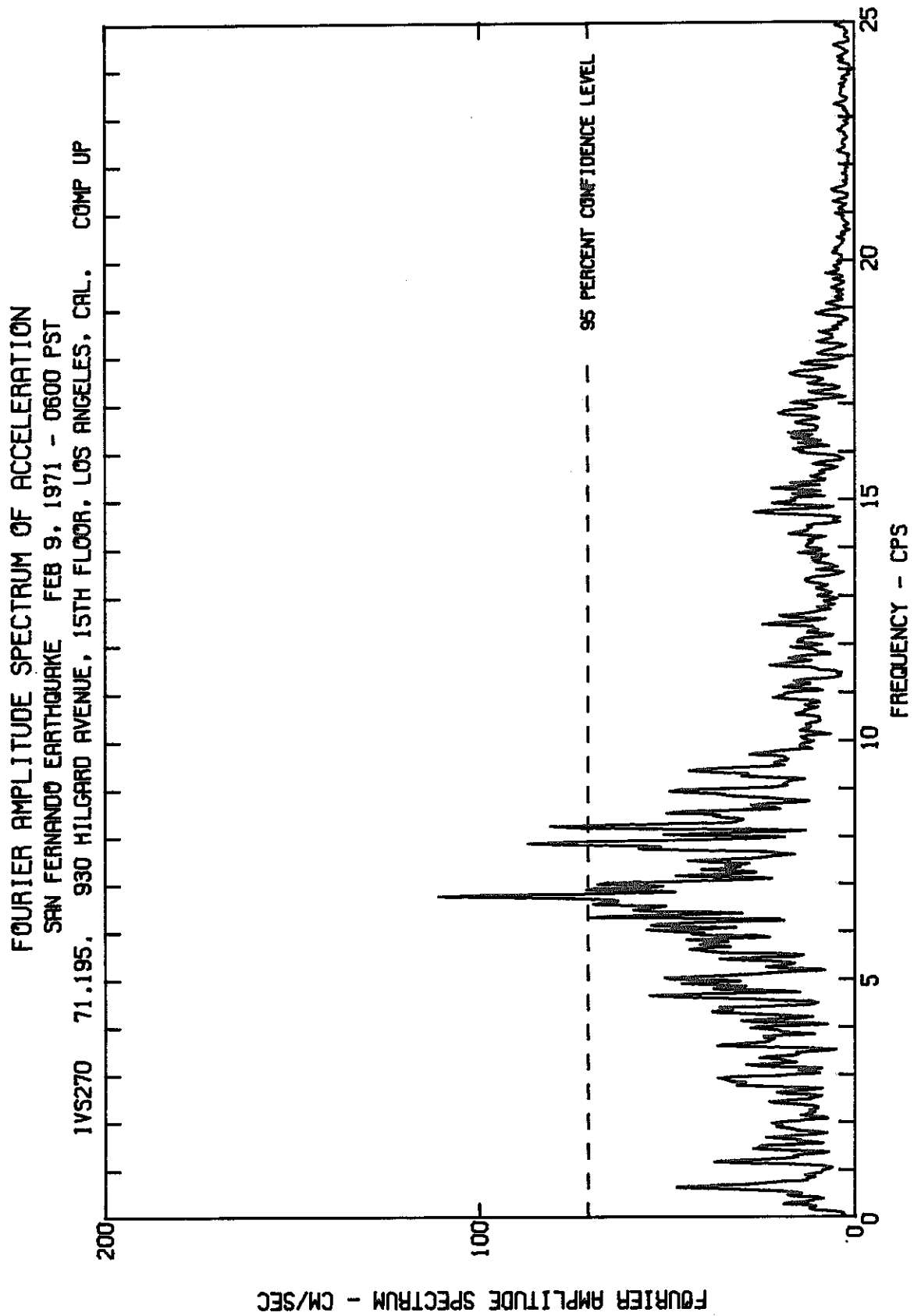


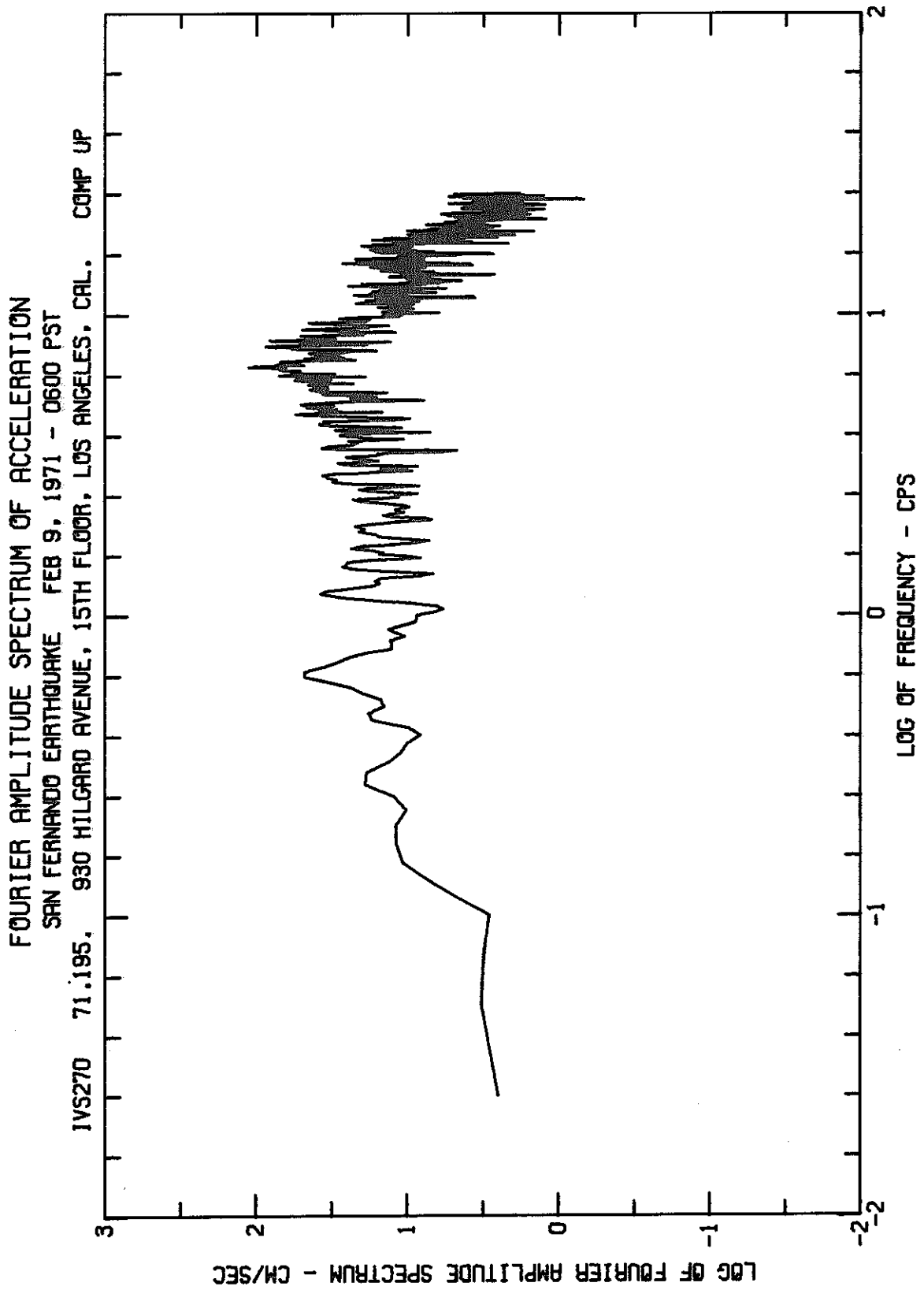
1VS270 71.195. 930 HILGARD AVENUE, 15TH FLOOR, LOS ANGELES, CAL. COMP NI4E
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

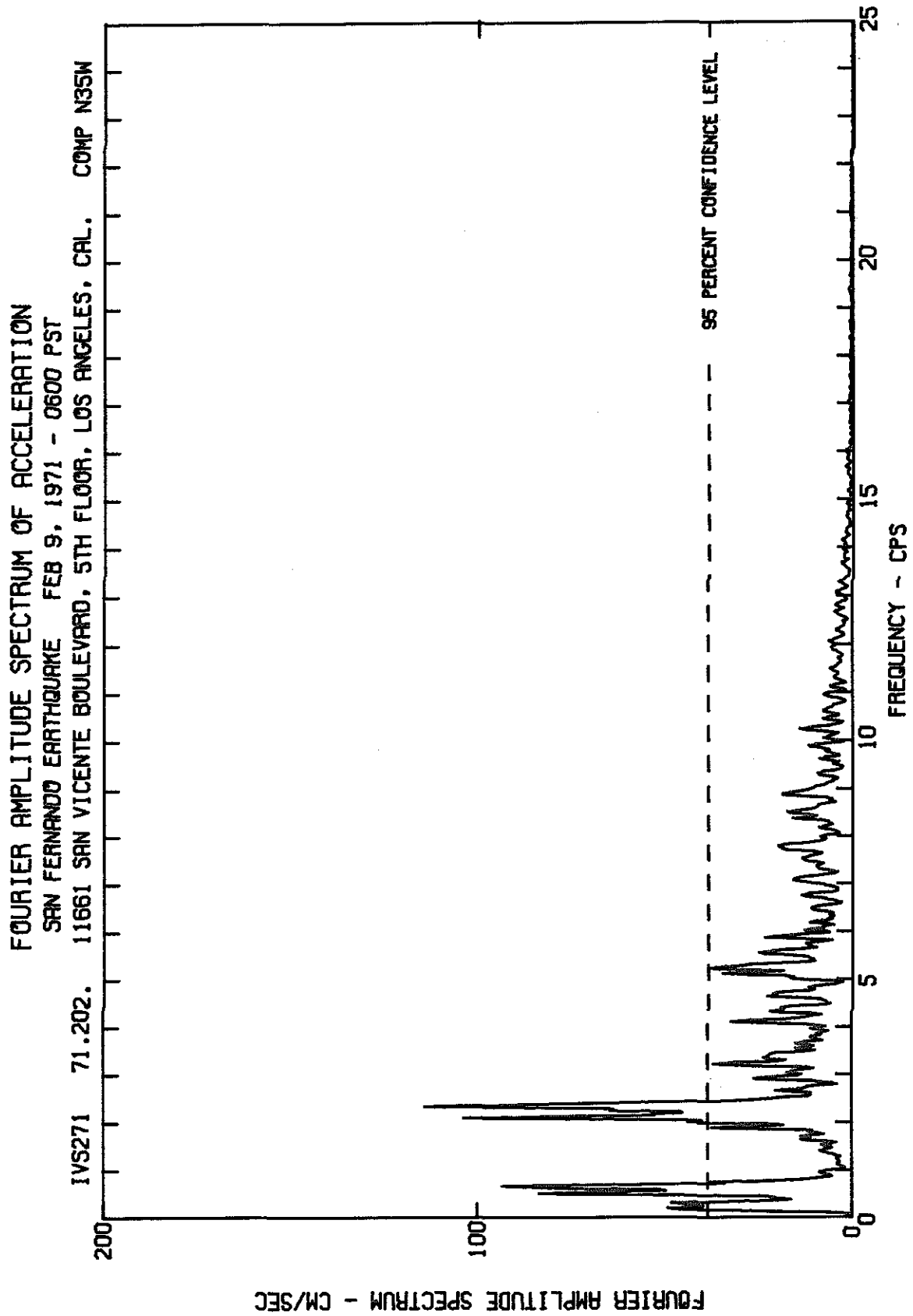


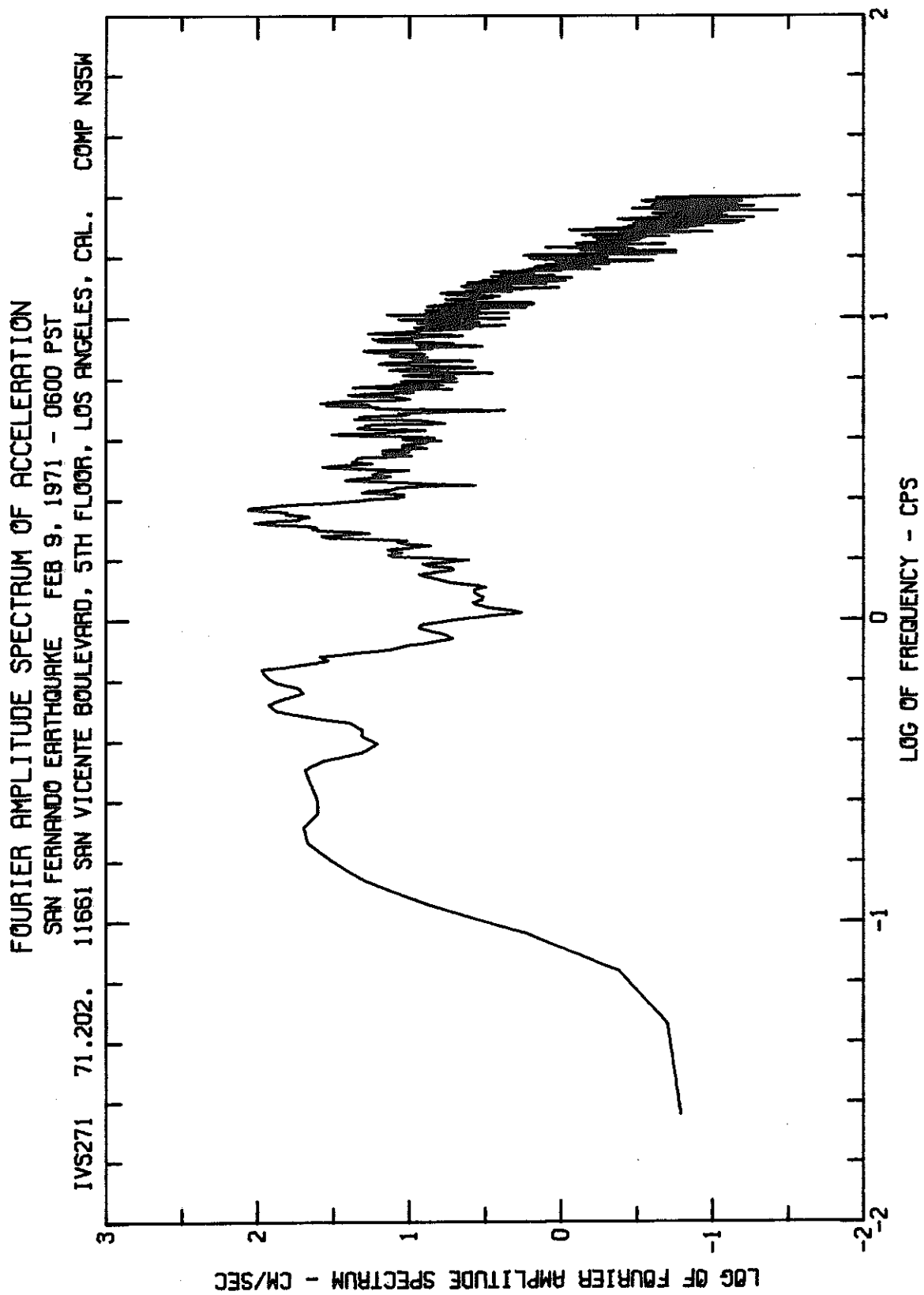


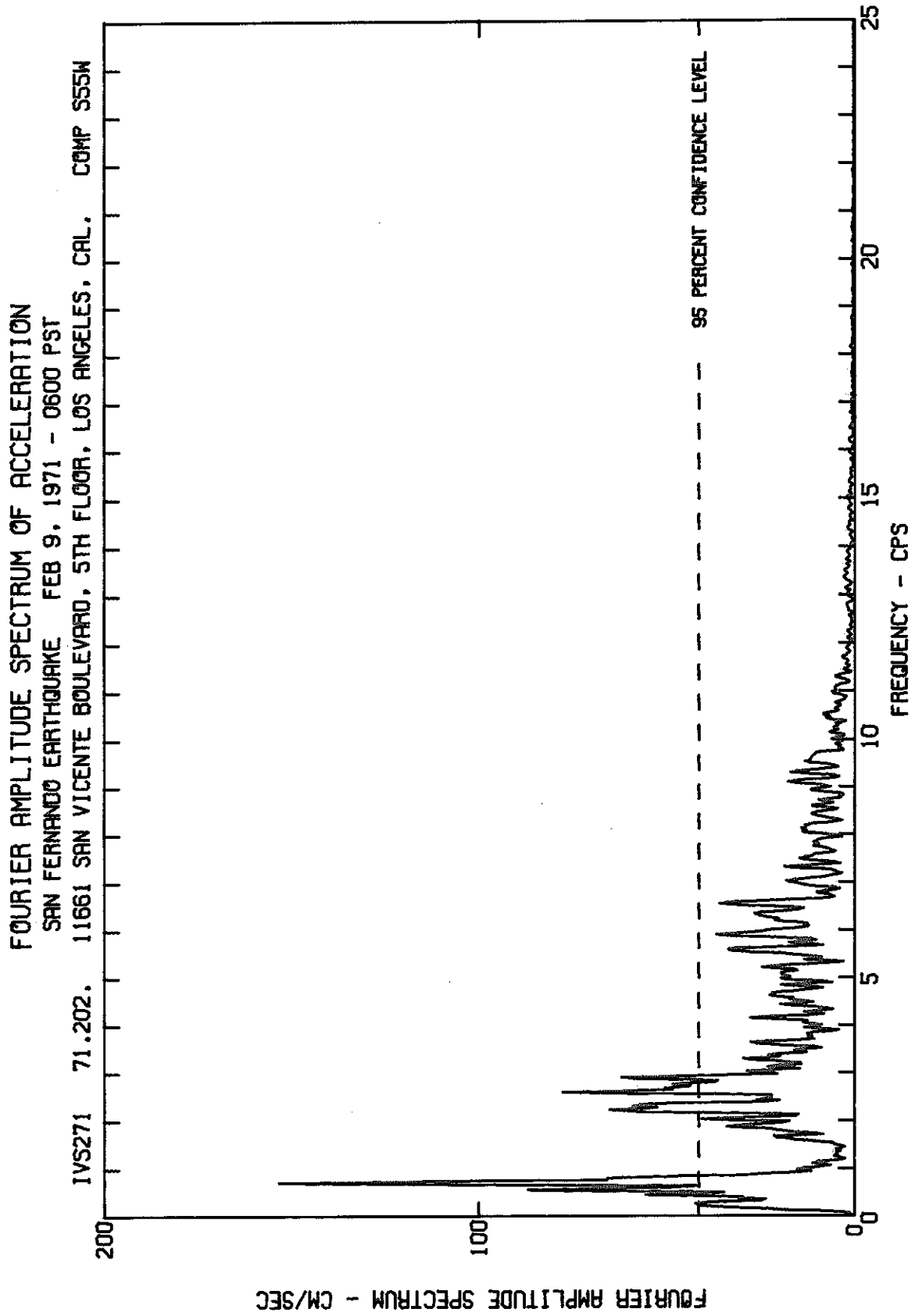


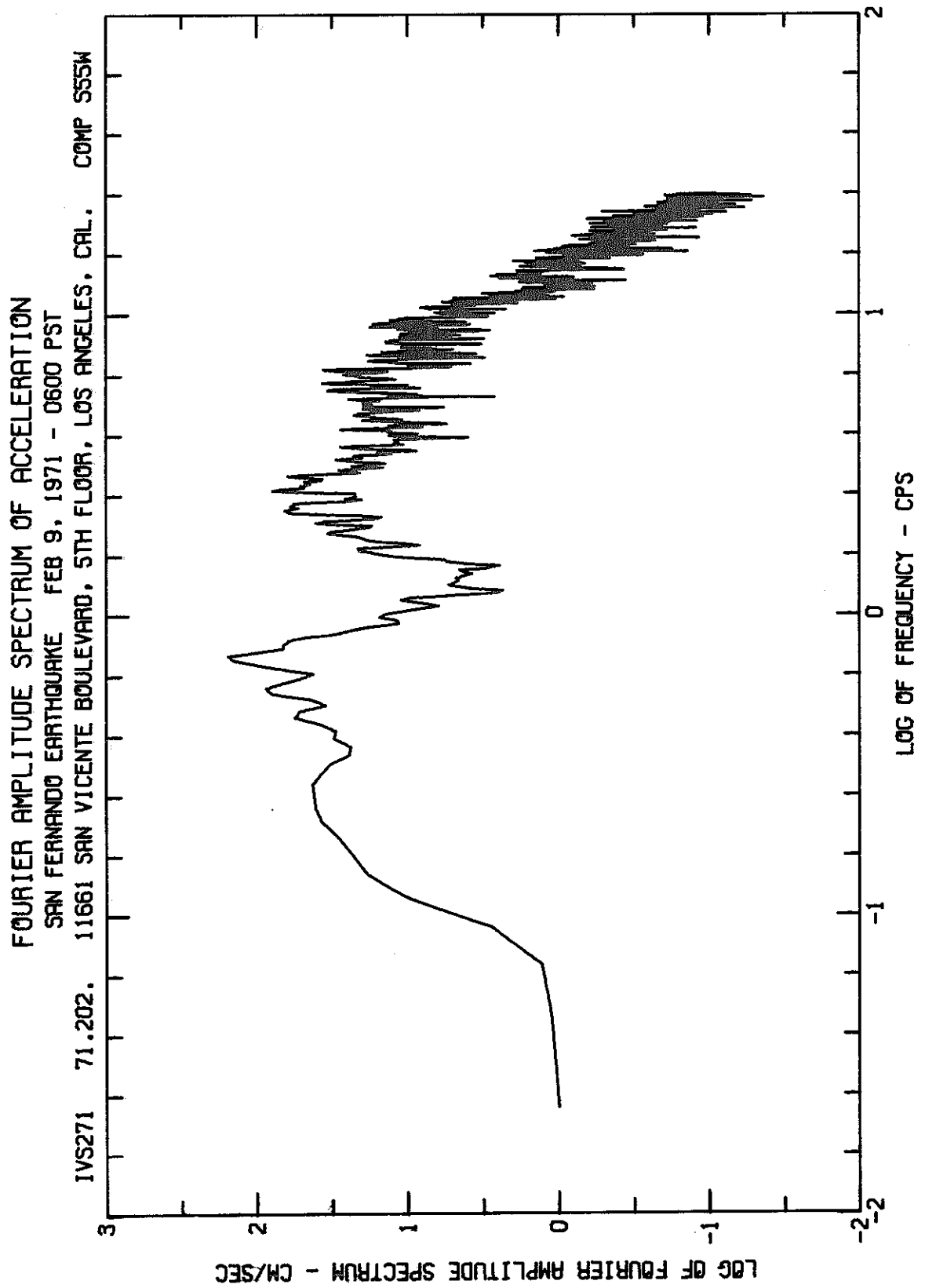


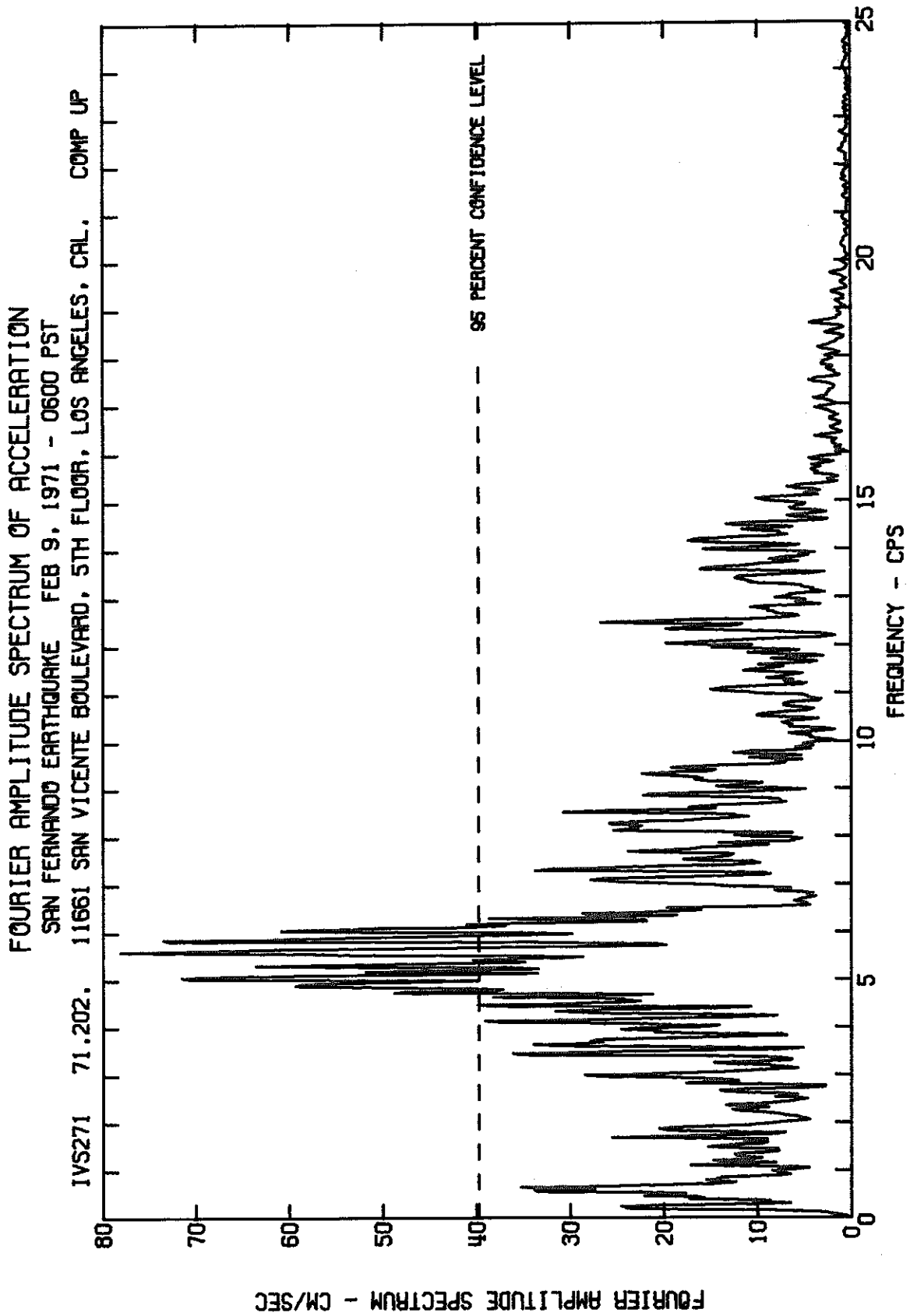


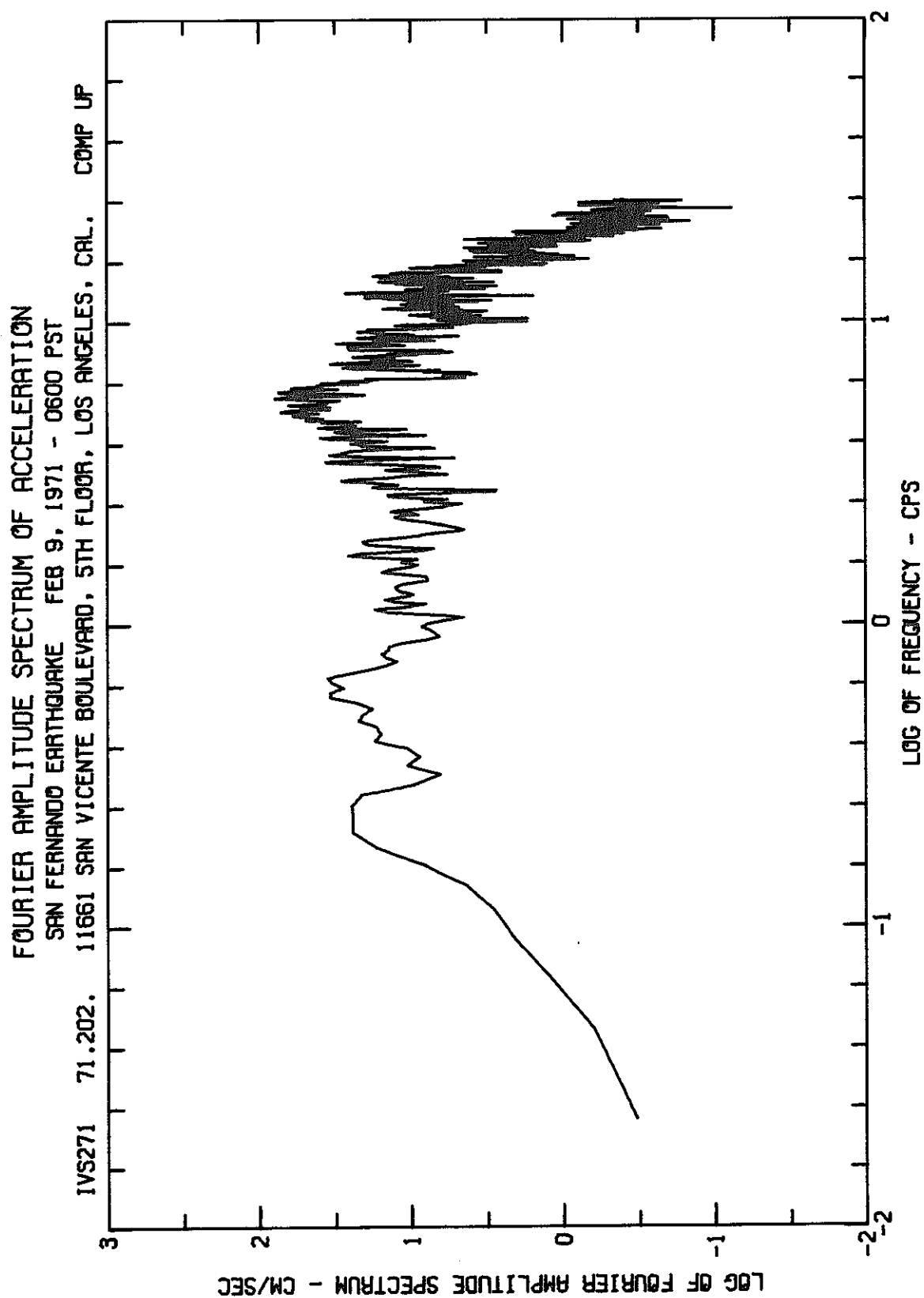


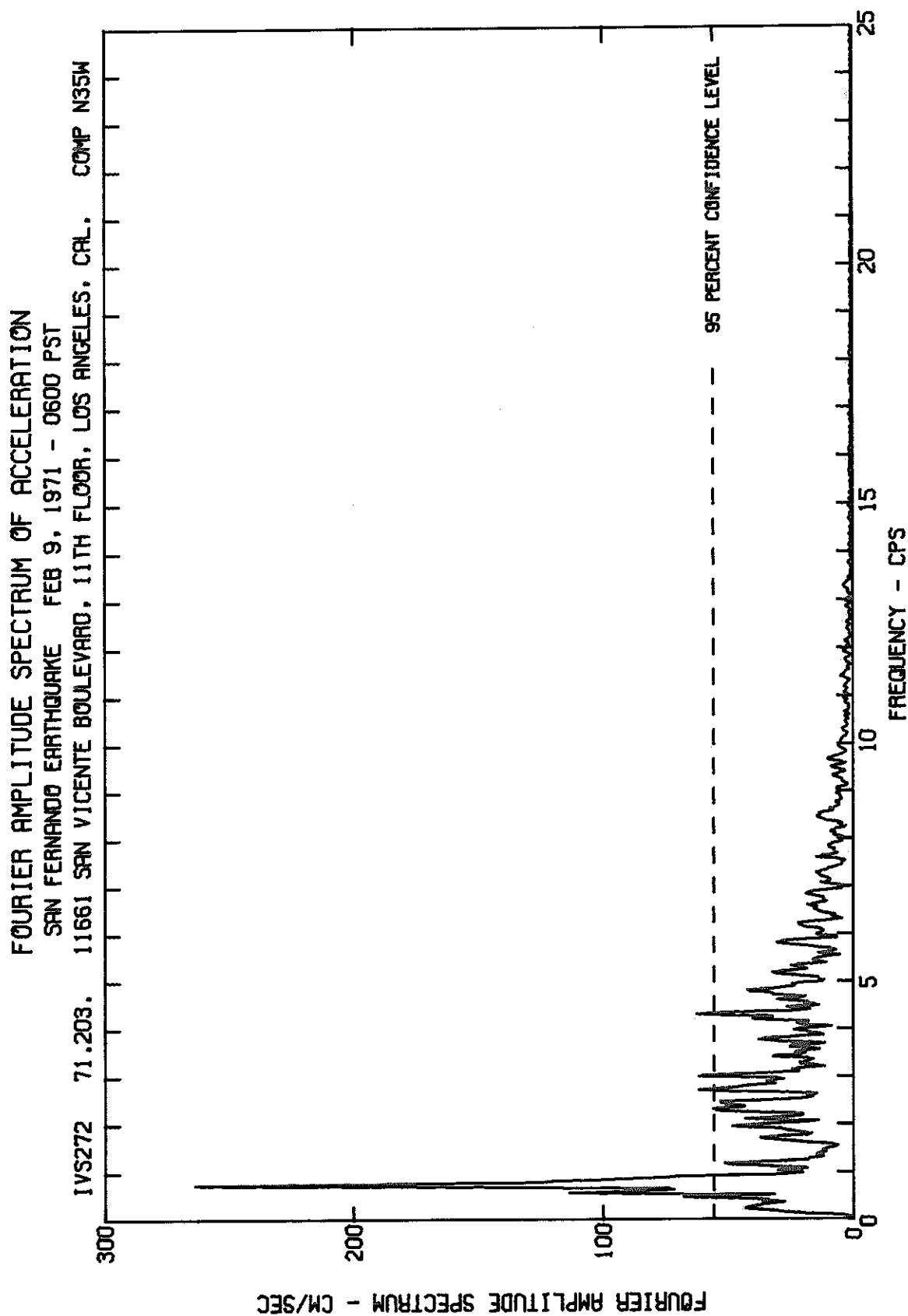








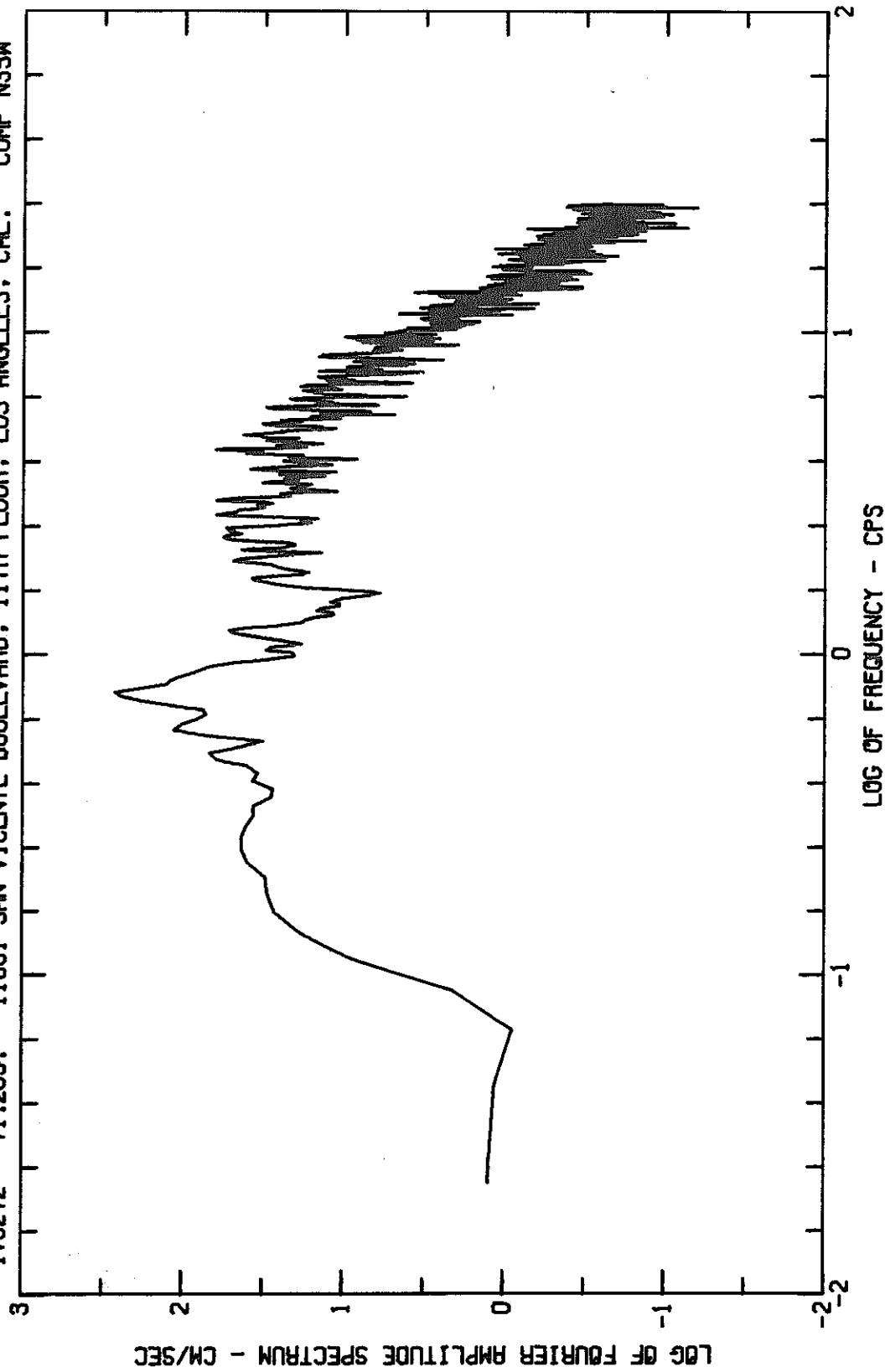


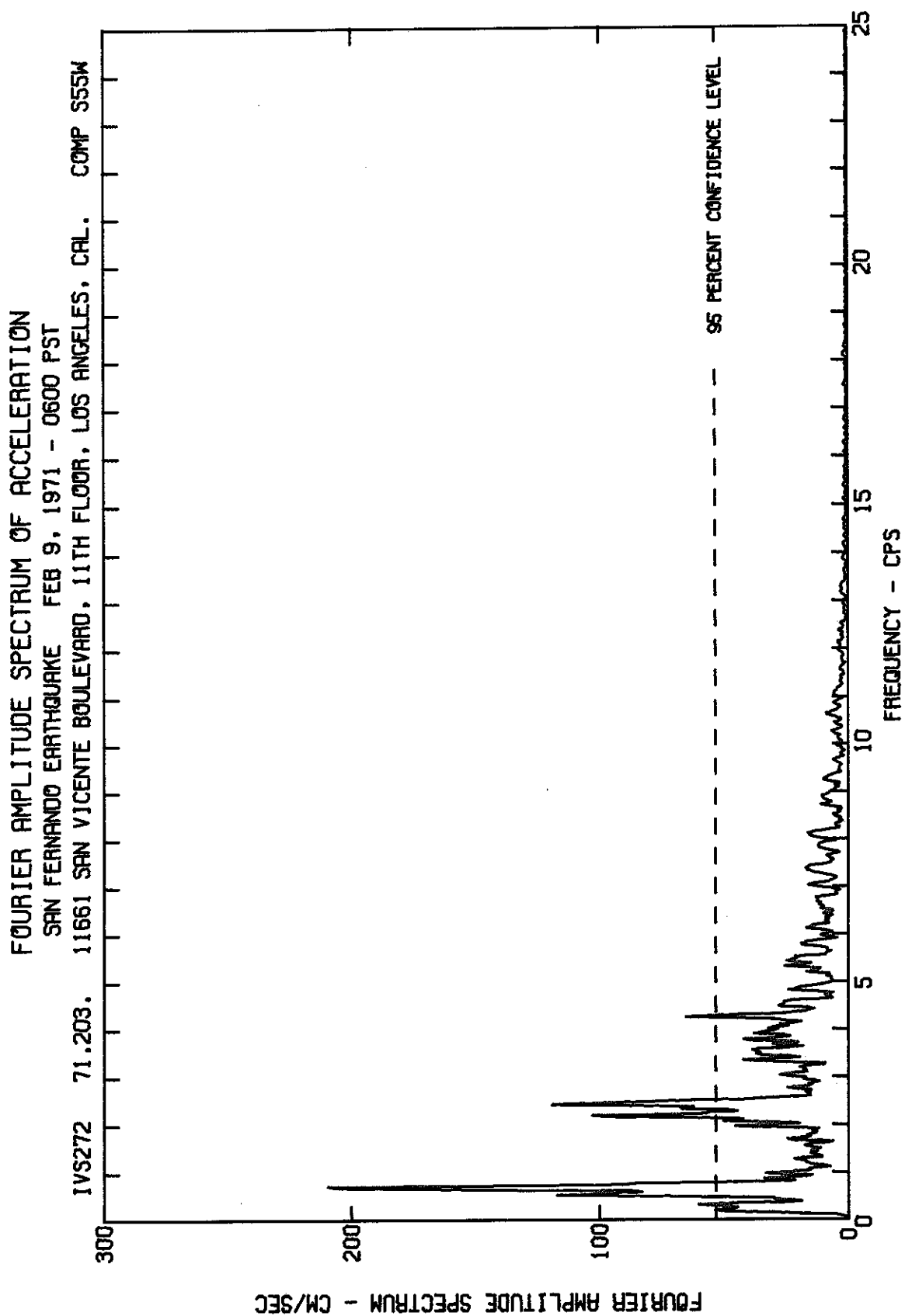


FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

IVS272 71.203. 11661 SAN VICENTE BOULEVARD, 11TH FLOOR, LOS ANGELES, CAL. COMP N35W

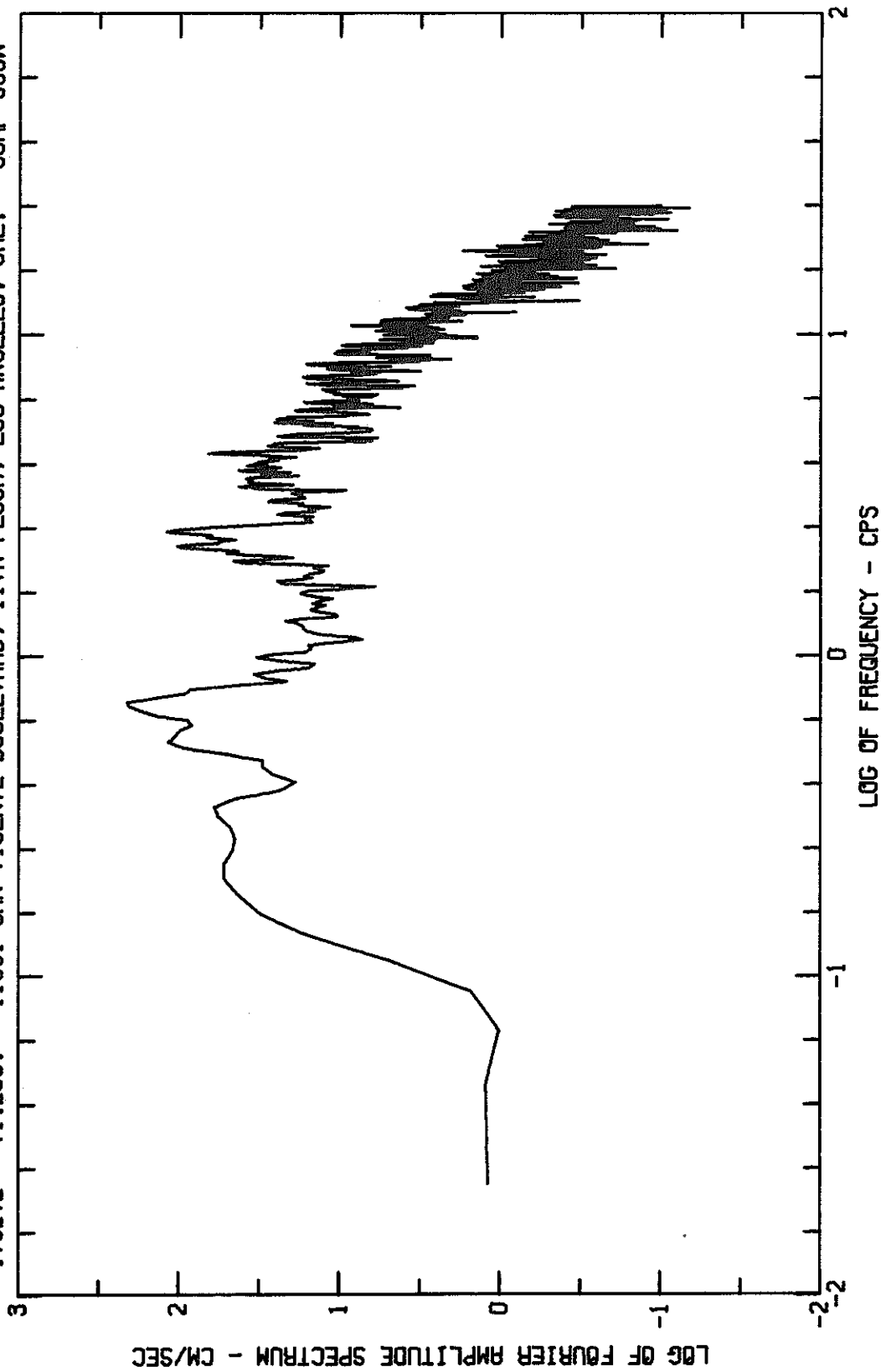


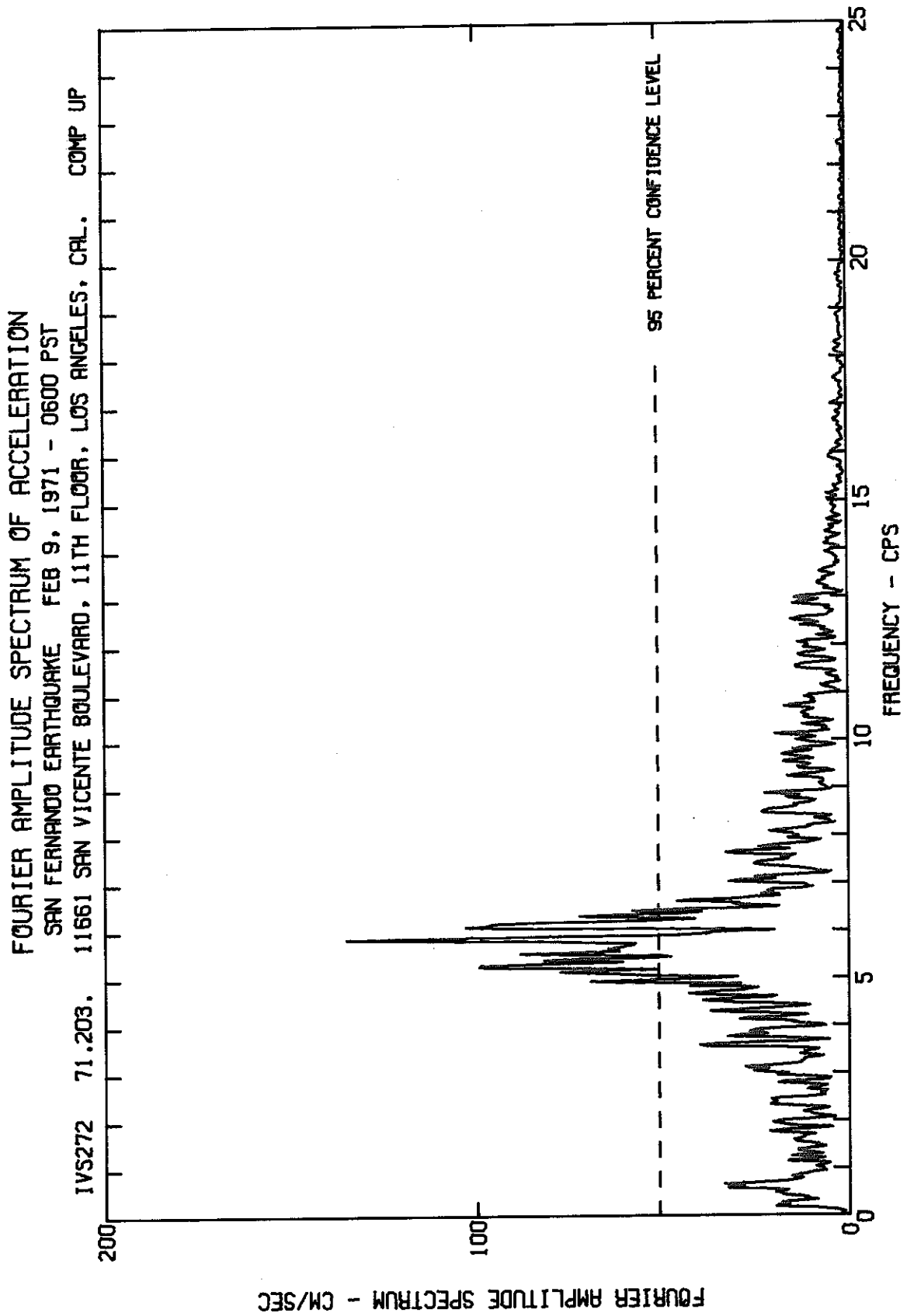


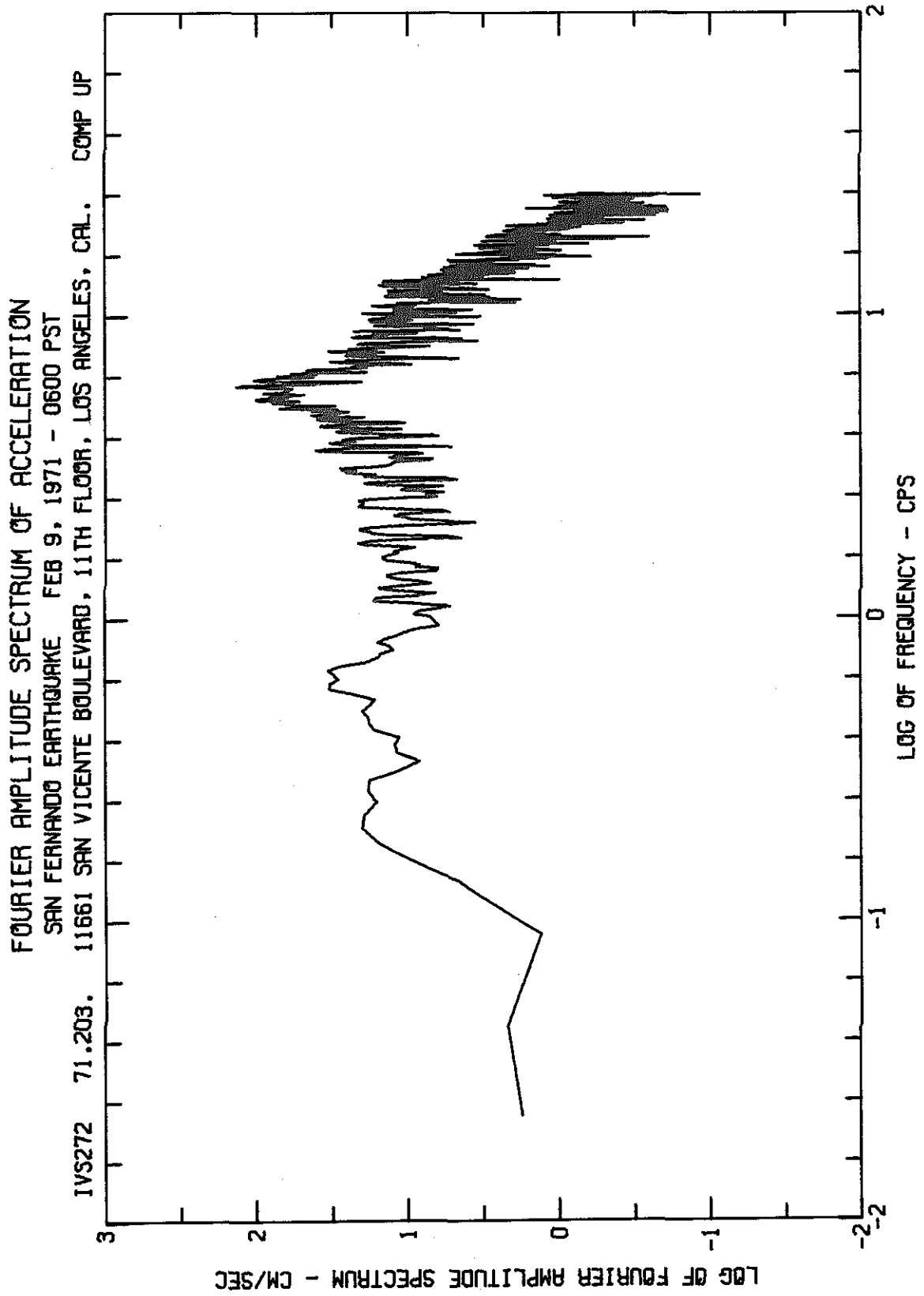
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

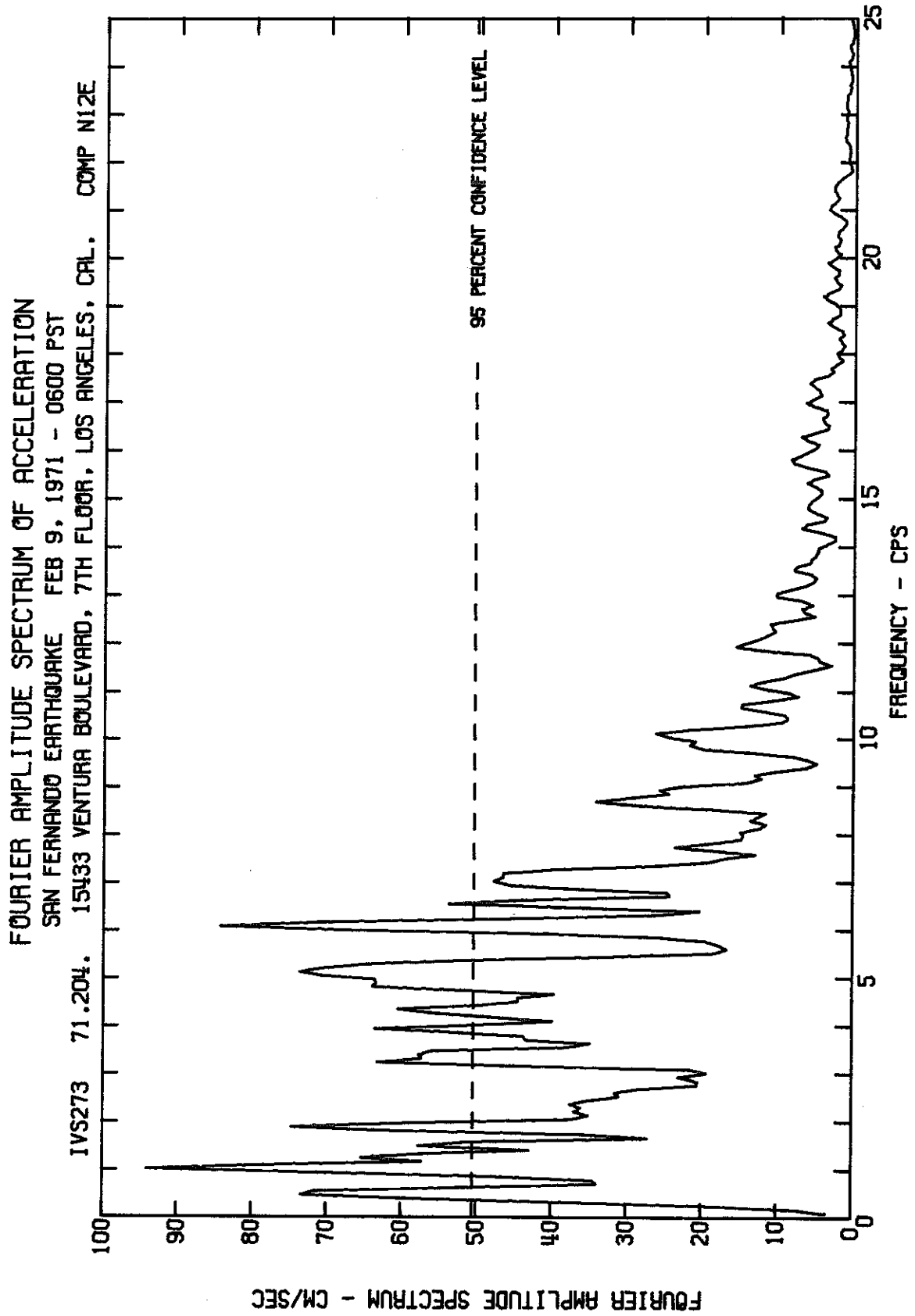
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

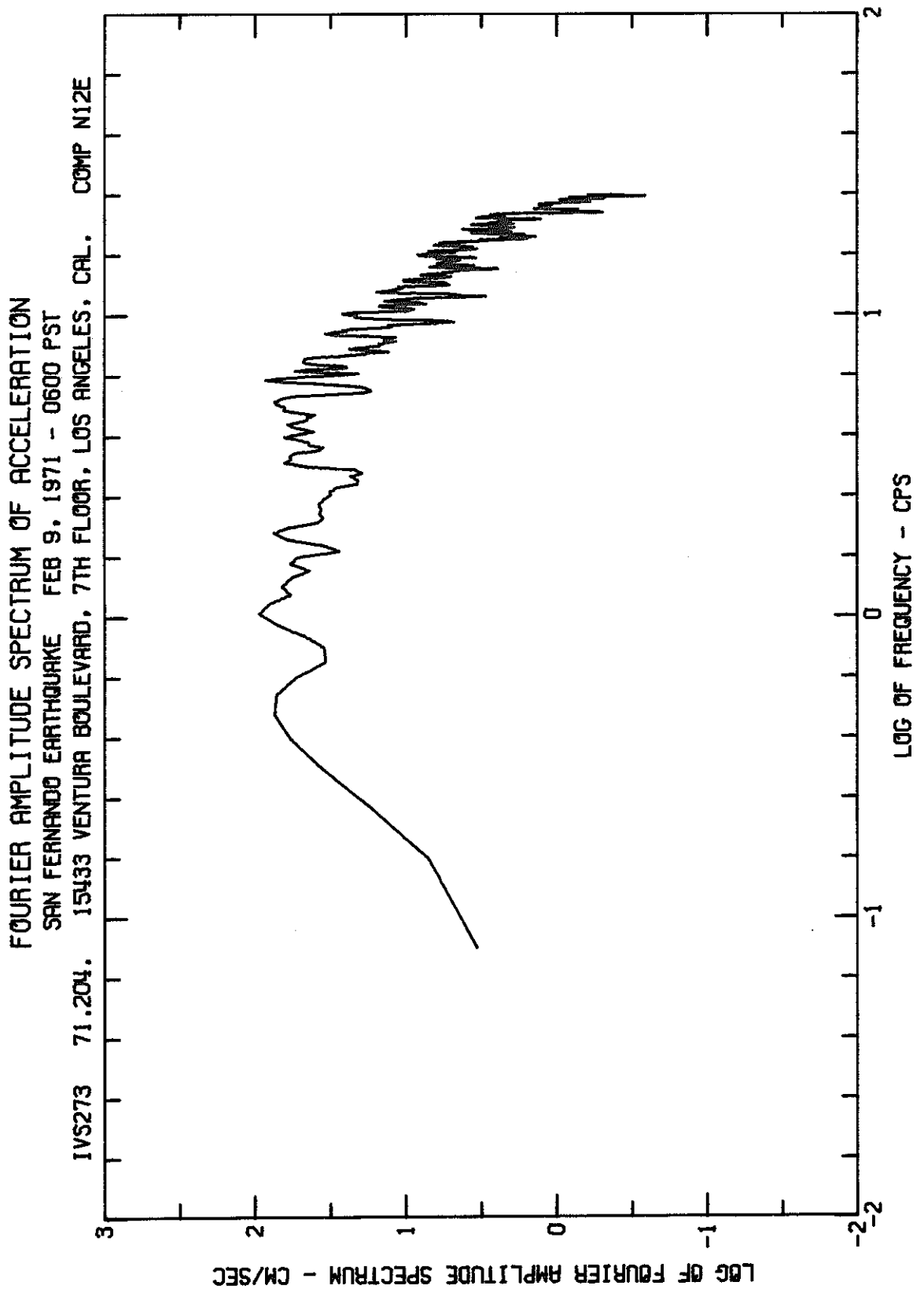
1VS272 71.203. 11661 SAN VICENTE BOULEVARD, 11TH FLOOR, LOS ANGELES, CAL. COMP S55W







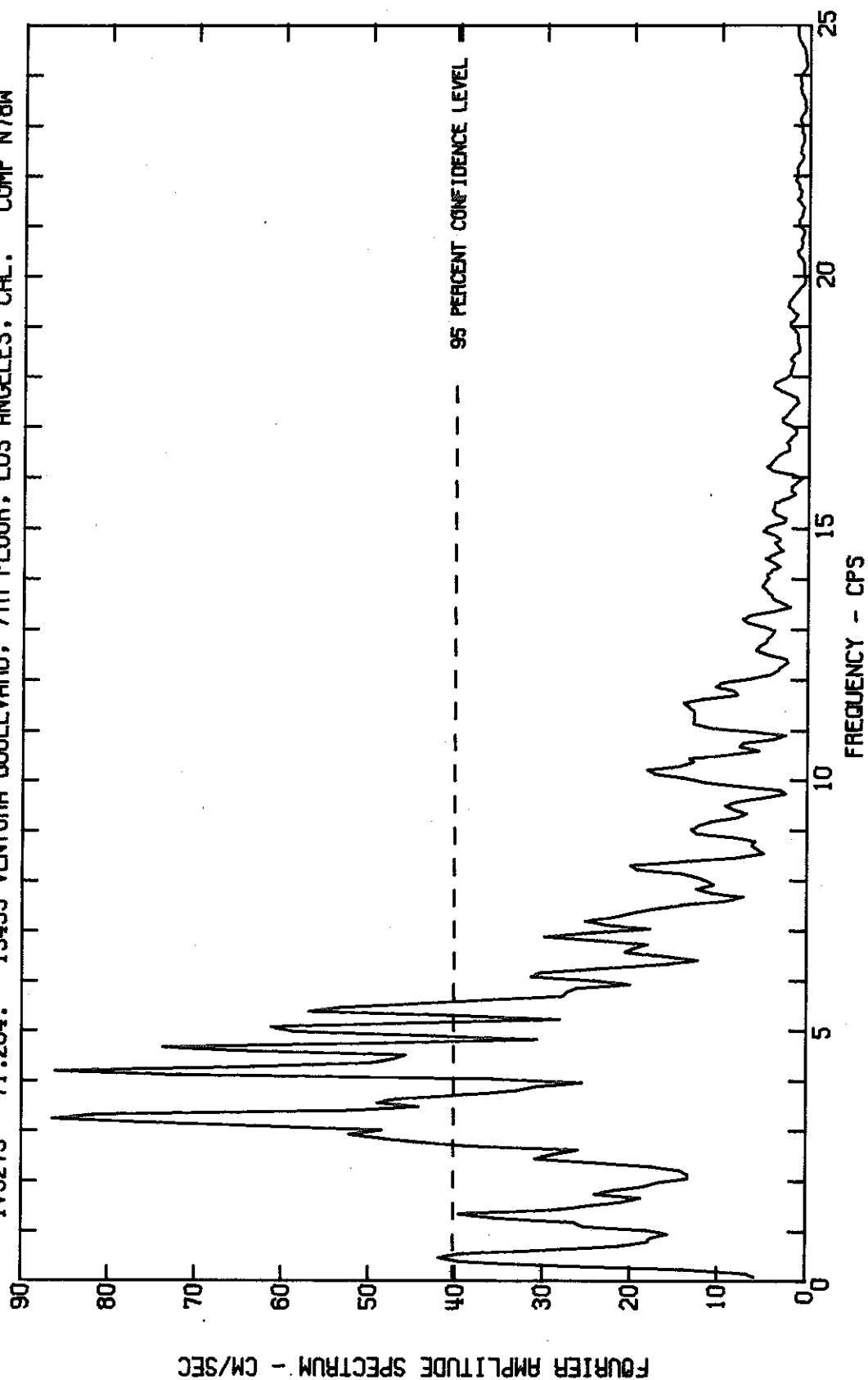


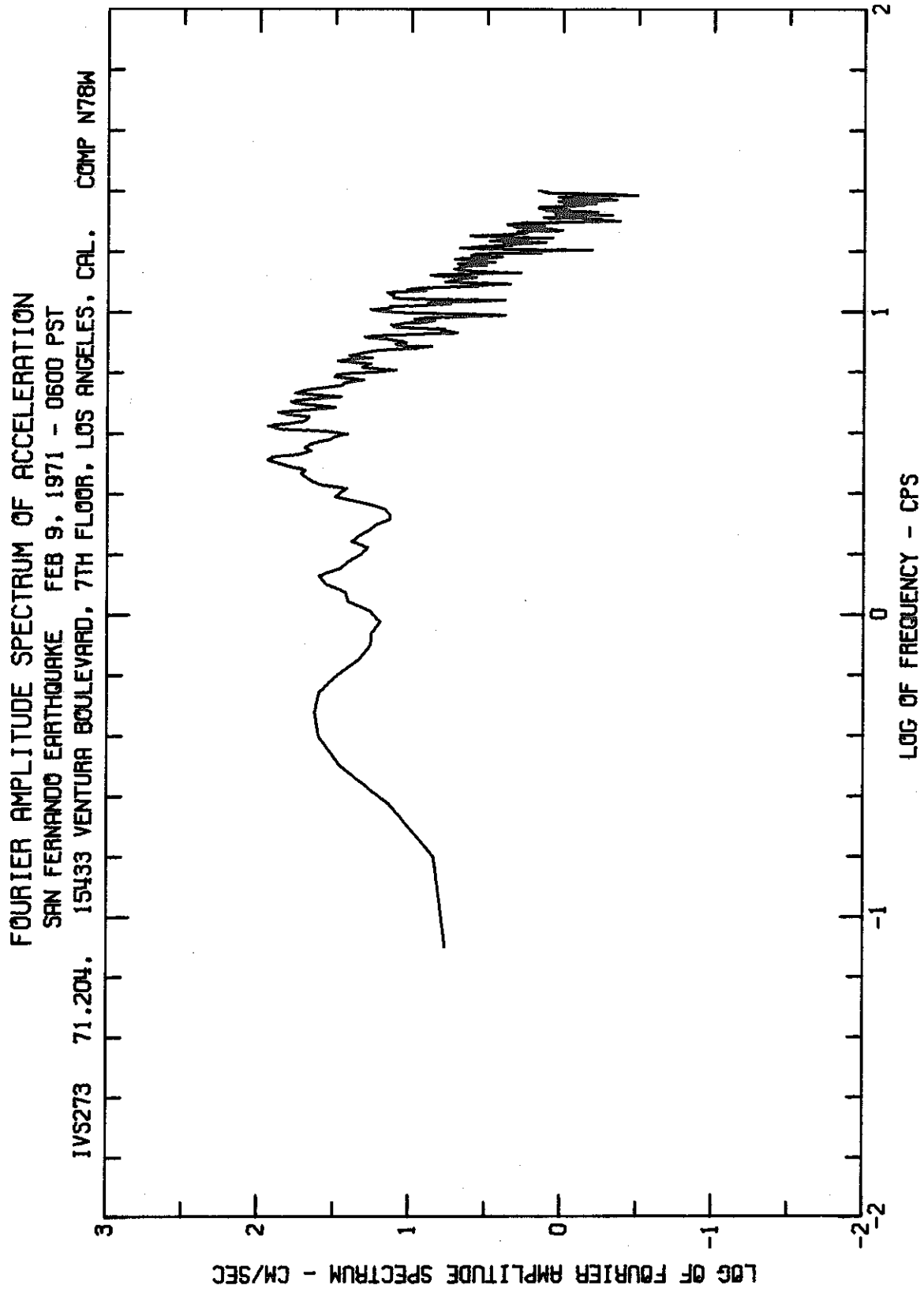


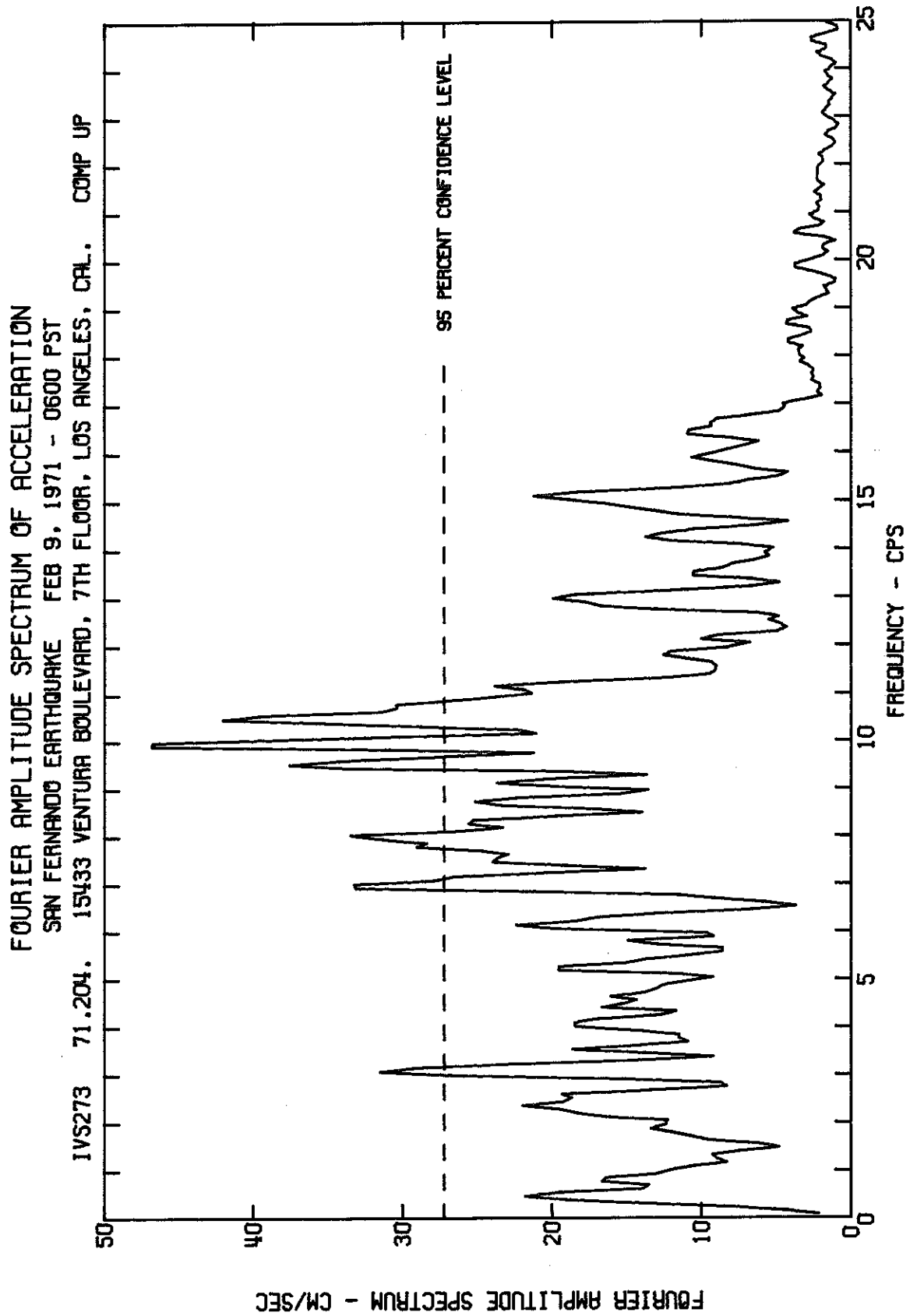
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION

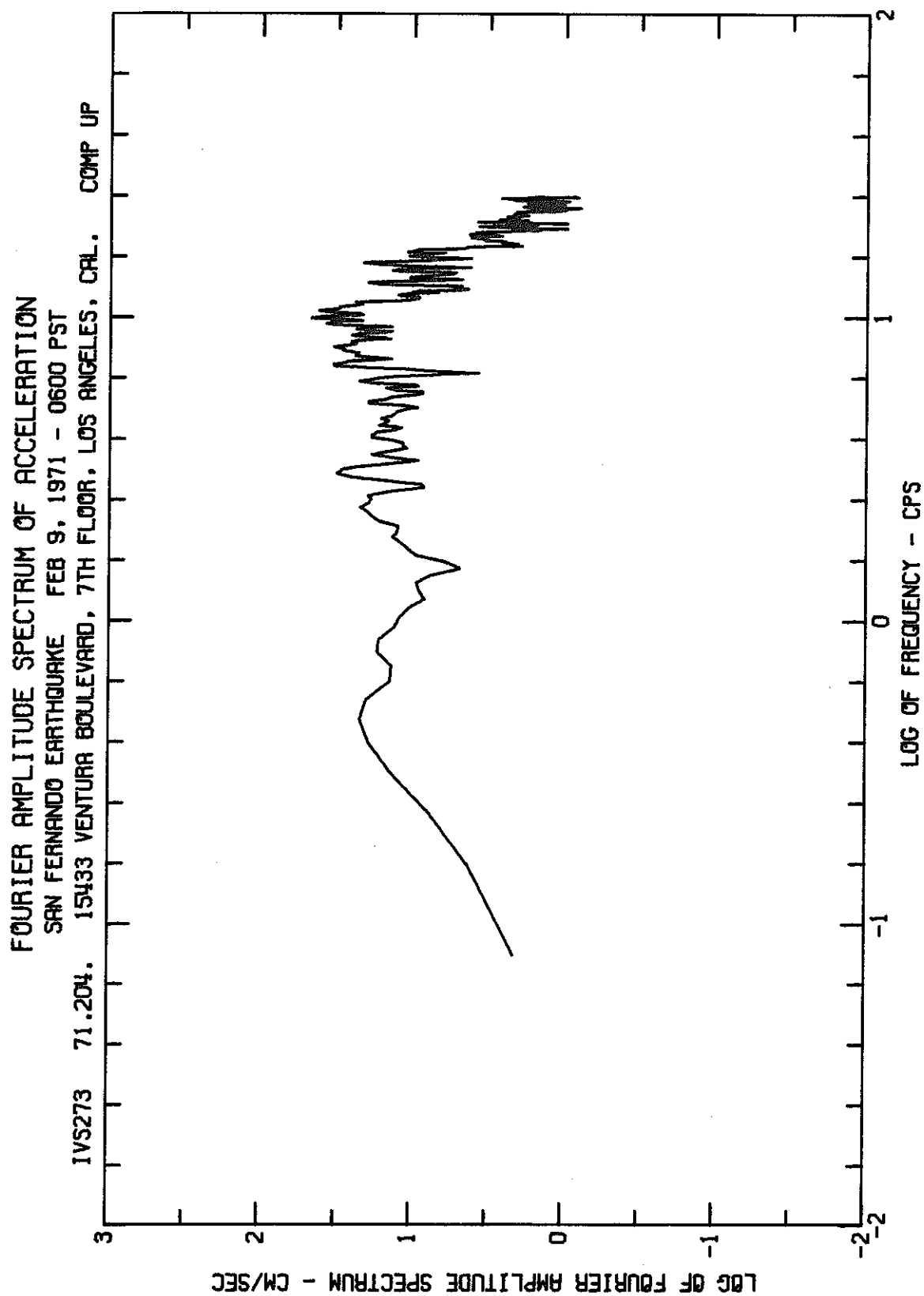
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

IVS273 71.204. 15433 VENTURA BOULEVARD, 7TH FLOOR, LOS ANGELES, CAL. COMP N78W









California Institute of Technology
Earthquake Engineering Research Laboratory

The following reports of the Earthquake Engineering Research Laboratory from 1970 on can be obtained from the National Technical Information Service, Springfield, Virginia 22121:

EERL 70-20	Strong-Motion Earthquake Accelerograms - Digitized and Plotted Data (Vol. I, Part A)	PB-287 847
EERL 70-21	" " (Vol. I, Part B)	PB-196 823
EERL 71-20	" " (Vol. I, Part C)	PB-204 364
EERL 71-21	" " (Vol. I, Part D)	PB-208 529
EERL 71-22	" " (Vol. I, Part E)	PB-209 749
EERL 71-23	" " (Vol. I, Part F)	PB-210 619
EERL 72-20	" " (Vol. I, Part G)	PB-211 357
EERL 72-21	" " (Vol. I, Part H)	PB-211 781
EERL 72-22	" " (Vol. I, Part I)	PB-213 422
EERL 72-23	" " (Vol. I, Part J)	PB-213 423
EERL 72-24	" " (Vol. I, Part K)	PB-213 424
EERL 72-25	" " (Vol. I, Part L)	PB-215 639
EERL 72-26	" " (Vol. I, Part M)	PB-220 554
EERL 72-27	" " (Vol. I, Part N)	PB-223 023
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EERL 73-22	" " (Vol. I, Part Q)	PB-232 315/AS
EERL 71-50	Strong-Motion Earthquake Accelerograms - Digitized and Plotted Data: Corrected Accelerograms and Integrated Ground Velocity and Displacement Curves (Vol. II, Part A)	PB-208 283
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EERL 74-54	" " (Vol. II, Part N)	PB-236 399/AS

EERL 72-80	Analyses of Strong Motion Earthquake Accelerograms - Response Spectra	(Vol. III, Part A)	PB-212 602
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EERL 73-81	" "	(Vol. III, Part C)	PB-223 025
EERL 73-82	" "	(Vol. III, Part D)	PB-227 469/AS
EERL 73-83	" "	(Vol. III, Part E)	PB-227 470/AS
EERL 73-84	" "	(Vol. III, Part F)	PB-227 471/AS
EERL 73-85	" "	(Vol. III, Part G)	PB-231 223/AS
EERL 74-80	" "	(Vol. III, Part H)	PB-231 319/AS
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EERL 72-100	Analyses of Strong Motion Earthquake Accelerograms - Fourier Amplitude Spectra	(Vol. IV, Part A)	PB-212 603
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EERL 74-102	" "	(Vol. IV, Part J, K, L, M)	PB-236 111/AS
Joint Report:	Strong-Motion Instrumental Data on the San Fernando Earthquake of February 9, 1971		PB-204 198
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EERL 71-05	M. D. Trifunac, F. E. Udwardia, A. G. Brady, High Frequency Errors and Instrument Corrections of Strong-Motion Accelerograms	PB-205 369
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EERL 73-02	Research Papers Submitted to the Fifth World Conference on Earthquake Engineering, Rome, Italy, 25-29 June 1973	PB-220 431
DRC 73-02	Earthquakes and Insurance, Published Papers on Earthquake Research Affiliates Conference of 2-3 April 1973	PB-223 033
EERL 73-03	M. D. Trifunac and V. Lee, Routine Computer Processing of Strong-Motion Accelerograms	PB-226 047-AS